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Sharpening the Cutting Edges

(This is one of the last steps in the manufacture of cutting tools at a plant of the Fisher Body Division of General Motors. The milling cutter shown probably will be used in the machining of tank parts at close tolerances.)

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GEORGE A. STETSON, *Editor*

Aviation at Los Angeles

WITHOUT minimizing the value and importance of other features of the 1943 Semi-Annual Meeting of The American Society of Mechanical Engineers held in Los Angeles in June, the program put on there by the Aviation Division of the Society and the splendid co-operation of the aviation industry of the Pacific Coast call for commendation.

In point of numbers of engineers registered at the meeting, Los Angeles proved itself capable of drawing larger audiences than the Society has attracted at similar meetings for many years. Thus the judgment of those who insisted that a Pacific Coast meeting would be well attended and serve to call the work of the Society to the notice of engineers of that vicinity was vindicated. The Aviation Division put a lot of planning and hard work into the effort and must consider itself amply rewarded. However, without the strong support of the aviation industry itself from which a major portion of the papers, as well as the audiences, was derived, planning and hard work would have been disappointing. Credit must also go to the members of the committees of the Los Angeles Local Section and particularly to the general chairman of the local committee, J. Calvin Brown, whom members of the Society in other parts of the country will have an opportunity to know better in years to come since he has been chosen by the Council of the Society to fill, for the remainder of the present administrative year, and by the Nominating Committee for the administrative year 1944, the unexpired term of Herbert L. Eggleston, resigned.

Looking back over the history of the Aviation Division since the close of the last war, members of the Society will recognize that the splendid showing of the Division at Los Angeles marks another increment in its growth. It will be recalled that aviation had few friends in the professional societies during the years that intervened between the close of the war and the building up of a lusty aviation industry. Not only did the A.S.M.E. maintain a professional division devoted to aviation (aeronautics was the term then used) during those years but its programs and publications afforded a recognized forum for engineers working in this field. From 1927 when A.S.M.E. Transactions were issued as publications of the divisions to the time they were combined and issued monthly, a quarterly known as *Aeronautical Engineering* was maintained by the Society.

In recent years the phenomenal growth of the aviation industry has justified a redoubling of the efforts of the A.S.M.E. to serve the engineer engaged in it. A reorganization of the Division was effected recently and Dr. John E. Younger, professor of mechanical engineering at the University of Maryland, was engaged to act as its secretary. The distinguished winner of the Spirit of St. Louis Medal in 1941, loyally supported by an equally distinguished committee, has devoted time, energy, and imagination to the improvement of the programs and publications sponsored by the Division. The Los Angeles Meeting program was constructed principally around the papers and discussions that he was able to secure for it as a result of an extended trip to the Coast last February.

In addition to its own technical and scientific problems the aviation industry faces and will always face the great variety of design, production, and managerial problems that are characteristic of the field of work in which mechanical engineers engage. The great strength of the A.S.M.E. in the aviation field, as indeed it is in any other in which these problems are important, lies in the breadth of knowledge and experience of its members and in the opportunity for cross-fertilization of experience and knowledge which is afforded in a society composed of engineers serving dozens of important industries. The successful and progressive engineer attends not only to the specialties of his own field but adapts the knowledge and methods developed in others, sometimes only remotely related to his own, to the problems that confront him from day to day. Experience at Los Angeles demonstrated that engineers in the aviation industry are keen to adapt to their own purposes the knowledge and experience accumulated by their fellow engineers and disseminated through the Society and also that they are contributing magnificently their own knowledge and experiences to the common store from which all mechanical engineers may draw. The A.S.M.E. is deeply grateful to the excellent co-operation it received from the aviation industry of the Pacific Coast. With the inspiration of the Los Angeles experience the Society will forge ahead with renewed vigor in its services to this great new industry.

Biomechanics Committee

LAST month in these pages attention was directed to the possibility of utilizing the principles of biomechanics in the design of aircraft along lines that should afford greater safety to the lives of pilots. It was pointed out that orthopedic surgeons have special knowledge of the strong and weak features of the human body which should be utilized by designers when aircraft, and particularly aircraft cockpits, are designed. It was stated that the problems involved are essentially within the responsibility of engineers to solve, with the advice and assistance of members of the medical profession who have made special studies in the field of biomechanics.

That The American Society of Mechanical Engineers

has recognized the importance of the problem of correlating biomechanics with airplane design is proved by the formation, under the A.S.M.E. Aviation Division, of a committee composed of orthopedic surgeons, aeronautical engineers, and others interested in safety in aircraft design and operation.

The new committee held its first meeting in New York on July 15 and discussed plans for future development and action. Although it is too soon to announce the plans, members of the Society will be interested to learn that the project has been initiated. As progress develops, reports of it will be made public.

Readers of MECHANICAL ENGINEERING will recall that on several occasions through comments in these pages and papers published by the Society, the subject of biomechanics and its relation to mechanical engineering has been called to their attention. For bringing the subject to its notice the Society is chiefly indebted to Dr. Charles Murray Gratz, of New York, an orthopedic surgeon, who has written for MECHANICAL ENGINEERING on this subject in the past, and to the late Dr. George Karelitz, who assisted Dr. Gratz in the engineering technics employed in his studies. With the enthusiastic support of Dr. Karelitz, Dr. Gratz, who observed the effects of crashes in the Pacific immediately after Pearl Harbor and became convinced that better correlation of his profession with the engineers would have important effects in saving lives and reducing the severity of crash accidents, brought his energy to bear on the A.S.M.E. Aviation Division and persuaded it to set up the new committee.

The work which the new committee is planning to do is of utmost significance as a further example of cooperation among learned professions for the benefit of mankind. The promise of long-term results is most encouraging. Once more the Society has accepted a challenge to broaden the scope of its services to the public in a manner which should greatly benefit engineering and the aviation industry as well. Engineers welcome this very concrete evidence of the willingness of the medical profession to assist it in a field in which the interests and knowledge of both are concerned.

Patent Sense

SO much sound and fury are expended over the patent system that the layman, who is not definitely lined up with its proponents or opponents, finds himself confused. When an attempt is made to present both sides of the case from the public utterances or writings of those who think we have got along rather well with it and those who wish to make radical changes in it, we are confronted with the dilemma raised by Mr. Bishop in the review which appeared on pages 525 and 526 of the July issue. Into this confused and sometimes emotional situation the recent report of the National Patent Planning Commission providentially appears with its clear statements: "The American people and their government should recognize the fundamental rightness and fairness of protecting the creations of its inventors by the patent grant. The basic principle of the present system should be preserved. The system has contributed to the growth and greatness of our nation . . . The American patent system is the best in the world . . . ." but it "should be adjusted to meet existing conditions without destroying its basic principles."

A brief summary of the National Patent Planning Commission's report, prepared by A. A. Potter, past-president A.S.M.E., who served as executive director of the Commission, will be found on page 564 of this issue. Engineers particularly will be interested in the report and its conclusions and will be grateful to Dean Potter for his service to the Commission. They will also be gratified at the terse and common-sense presentation of problems and conclusions and will look forward with interest to the reports of future studies which the Commission has under way. They will also hope that the Congress will recognize the high quality of the report and give serious consideration to its recommendations. For it seems possible that a way has been found by which the best and basic features of this great instrument of free enterprise, encouragement of initiative and resourcefulness, and demonstrated means by which the "growth and greatness of our nation" was stimulated can be improved without being destroyed.

Future of Education

ALTHOUGH formal education is suffering severe dislocations as a result of the war, only a defeatist will take the attitude that no good will come of them.

The war has given us a renewed confidence in the value of education, for one thing. Whether it be on the college level or at the trade level, education and training have become essential to the winning of the war. Scarcely a single department of human knowledge has failed to serve the nation in the present emergency. Even where obscure specialists have failed to make primary contributions, the trained minds of the specialists have been adapted to the needs of the times.

We shall undoubtedly emerge from this war with a renewed respect for vocational education in its broadest sense. Men and women who know something and can apply that knowledge usefully are sorely needed in wartime. They are needed also in times of peace. To provide opportunity for trained persons to make use of what they know in the work of the world is one of the great tasks of the immediate future.

There is a wide range of useful activity for men and women who have the intellectual capacity to apply their knowledge usefully in fields that were the concern of a few experts before the war. We shall be closer than ever before to the peoples of other nations. Our destiny will be mingled with theirs. To educate large groups of young people for living intelligently in the new postwar world will provide a stimulating opportunity for reinvigorated college curricula. Problems to be solved at home will also call for the practical approach to education, especially at the higher levels, which is cultural in the broadest sense of the term and truly vocational in character.

The war has demonstrated the value of engineering education. Peacetime conditions will not diminish the need for engineers but rather will increase it. A high level of competence will be demanded, and with it there will also be demanded a deeper appreciation of the significance of engineering in the life of the world.

The APPLICATION *of* AIR POWER

By GENERAL E. P. SORENSEN

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IT will be of interest that a paper[1] was presented at a meeting of this Society 35 years ago, on the subject of the "Present Status of Military Aeronautics." The presentation was made by the then Major, Signal Corps, later the Chief Signal Officer of the United States Army, General George O. Squier. Even now that paper makes interesting reading. Some of the predictions given for the future of military aviation have proved to be quite correct.

Considering the status of military aeronautics in 1908, we can easily excuse the author for one prediction which has not been borne out by developments. In further excusing the author for his statement that the airplane is likely to prove a flying machine of comparatively low tonnage, it may be said that it was only a few years ago that airplane designers could prove that there was about a 50,000-lb limit to the economical size of heavier-than-air craft. Neither should we be too severe with the designers whose proof of that theorem has "gone with the wind," because we must recognize that design is so intimately dependent upon the materials available to them for construction. As will be recognized, the remarkable progress in the performance of present-day aircraft over those of a few years ago is by no means attributable to design genius alone but must be credited in great part to the increasingly high quality of materials of construction.

Many of us—the majority, perhaps—have listened, astonished and puzzled, to the controversy which is always provoked by the mention of "air power." What is its scope, its importance, and its true function? What are its weaknesses?

We are generally unanimous in the opinion that air power—whatever it is—must be something of vital national importance, but there seems to be no agreement as to what it really is. We see arrayed, not on two sides but on many sides, men in whom we have the highest confidence and who are sincere and capable in their fields. Each argument has its obvious merits, yet the many ideas appear to be irreconcilable.

WHAT IS AIR POWER?

Before I can discuss the "application" of air power I must first answer that question, at least as well as I can to my own satisfaction, by reason and logic. I can cite examples, but they too must depend upon logic for their proof, because air power, whatever its composition and scope, is but an infant without past accomplishments on a major scale to prove its real talents or weaknesses.

In my opinion, air power is now possibly little more advanced than was sea power at the time Phoenician traders were arming their galleys for use in raiding other shores. Perhaps we are almost on the threshold of a development in the air concept analogous to the British proof that real sea power was an inseparable combination of armed fleets and commercial shipping. Commercial shipping was necessary to her existence, and sea force was necessary to clear the way for her shipping.

In any event, Britain proved the soundness of this thesis for an island nation in a world mostly water, and we cannot fail to see that every nation is an island when we consider the ocean of air to which all have access.

This quite naturally leads to the conclusion that the real subject of this discussion is not "air power" but "air force." The two terms are not synonymous.

Air power embraces the entire air problem, including commercial and private air activities as well as the military aspects. It includes the factories, the air lines, and the private fliers, while air force is but one part made possible by the others.

AIR FORCE THE MILITARY ARM OF AIR POWER

Air force is only that part of the national air power which is devoted to military operations; strategic, logistic, and tactical. This, of course, is the part which is of paramount interest today, and therefore it is the only part under discussion. I have mentioned the whole problem merely to define this part, leaving the other aspects to be relegated to their proper places by our leaders in the natural course of events.

Air force is not a simple subject for discussion, and it is the more difficult because of its comparatively recent birth. Implementation of an air force demands a clear conception of the functions which it is to perform. An air force may include many categories of special aircraft. As between them there is a good measure of flexibility as to employment. This measure of flexibility must not, however, confuse the issue of demanded superior performance of each type in its own specialty. As is well known, airplane design involves many compromises—a single design cannot excel in everything.

Air power revolutionizes in many respects but does not necessarily outmode older concepts of warfare. It lengthens our reach, ignores obstacles which deny movement to surface forces, increases the distance over which we can strike and the speed with which the blow can be delivered, but it does not change the basic principles of warfare.

Surface warfare must attempt to crush the resistance which guards the approach to the enemy's vitals. These are armed forces except where mountains or oceans can be made to serve. The armed forces may be attacked directly, but it is usual to attempt to deny reinforcements and supplies to the enemy on the battlefield. It has always been recognized that the killing of armed men is one means of attaining victory. It is also generally understood that much of the enemy ability to resist can be voided by interdiction of his supply channels.

Any army which is isolated from supplies and reinforcements soon becomes inert. Thus we see the effectiveness and economy of the single and double envelopment or encirclement as against the frontal attack.

Air force increases the scope or possibilities along those same lines. It enables us to assist our front-line forces by hitting the enemy in the immediate forefront and just behind his lines, attacking his supply dumps, his roads, and his strong points in much the same manner as ground artillery. But it is not as limited in range as is artillery to which it bears some similarity. The airplane can reach much farther into the interior of the enemy territory to deliver destructive blows on the vital sources far beyond the range of the most powerful ground guns.

INTERNAL BLOCKAGE OF THE ENEMY BY AIR FORCE

When the enemy occupies territory which is, to all practical purposes, self-sustaining, the destructive power of air force is of the greatest importance. Air power now permits the siege of a relatively self-sufficient nation, an internal siege that prevents the supply flow from inside sources to the fighting fronts. The possibilities of this internal blockade are no less real and ap-

[1] "Present Status of Military Aeronautics," by G. O. Squier, Trans. A.S.M.E., vol. 30, 1908, pp. 640–721.

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parent than are those of an encircling blockade which eventually so weakens an enemy that his circumference of defense is unable to put up effective resistance against frontal assault. Disintegration of defense, such as occurred recently in Tunisia, is but a logical consequence.

This thought points the finger directly at the outstanding capability of air force. It singles out the long-range bomber as the weapon which enables air power to serve as a primary instead of an auxiliary arm. It may still be necessary to hold and strike the enemy on his front lines by every means at our disposal on land, on the sea, and in the air, but the internal blockade, made possible by the long-range bomber, can be used independently to hasten the weakening of enemy resistance and to reduce the ultimate cost of the final assault. It is, on a big scale, a vertical envelopment for denial of supplies, munitions, and equipment to the enemy's fighting forces.

It is not necessary to belittle the importance of the ground-support capabilities of air force. These have often been demonstrated. The North African campaigns, the one from the East as well as the one from the West, which finally merged into the combined battle for Tunisia were classic examples of the use of fighters and bombers in direct support of ground forces. Rommel's long line of communications, and his ports, became a shambles through which supplies passed only at great cost. In Tunisia our fighters and light bombers raised havoc with tanks, trucks, and marching troops, while the supply dumps and troop concentrations never had a moment of safety.

But too often we have let the most obvious facts blind us to more fundamental lessons. Air superiority in the battle area was spectacular and complete, but it was not an end within itself. Air superiority permitted the fighter-bombers and the other planes to have almost free reign over the battle area, but that is not always enough. Last spring and summer the RAF maintained superiority over the German air force in Libya and Egypt, but though this helped considerably, it was not enough to prevent the German advance to the edge of Alexandria. There was something missing.

STRATEGIC BOMBING HASTENS AXIS LOSS OF AFRICA

Studying the later African campaign, we see the piece that was missing and we can identify it as "strategic bombing," the air action which prevented the delivery of essentials to the African area. A regiment of tanks operating on suitable terrain is a powerful unit. Many lives and much equipment are the usual cost of destroying such a unit belonging to the enemy. To destroy it while aboard ship by a few aerial bombs—sunk without a trace—is very welcome direct support to the ground force which would otherwise meet it on land. The Bismark Sea action was a classic example.

We can go back as far as March, 1942, for an example of air action which, beyond all doubt, contributed to the reasons why German defenses disintegrated so completely. It has been estimated that the RAF attack on the French Renault plant in March, 1942, denied the German army the equivalent of the heavy transport needed for over two and one half divisions. To do the same on the battlefield would have cost untold hundreds in casualties, but the RAF paid only a few airplanes and crews.

Bombing of steel mills, refineries, and other industrial units in Europe by the American Eighth Air Force and the RAF further weakened the flow in support to the German forces in Africa as well as elsewhere, while the British and American attacks on Axis Mediterranean ports made them almost useless. Allied fighter interceptions of huge Axis air-transport fleets contributed directly to the blockade, while the Axis needs for air protection against Allied air attacks over the continent cost many fighters and prevented adequate reinforcement of the dying Axis air force in Africa.

All in all, the Tunisian action was a beautiful example of co-ordination of all forces to attain final victory. Each served in its proper place. The campaign will live in history largely because its termination provides a convincing example of the effects of strategic bombing. Frontal assaults upon such a powerful enemy could succeed only in causing him to withdraw, except where a break-through might permit encirclement of certain forces. Instead of that common result, the German defense disintegrated spectacularly, as from interior decay. Individual units were still intact, yet they wandered around looking for Allied forces to whom to surrender. They could no longer fight as a complete army.

Many who argue against the value of air power use the "Battle of Britain" for what they consider proof positive of the futility of strategic bombing. No one questions the numerical supremacy of the German Air Force at that time, and no one can deny that it was used with devastating ruthlessness. Yet it certainly failed to bring England to her knees or even to wavering in her determination to keep fighting. Neither did it materially impair her industrial production.

GERMAN AIR FORCE KEYED TO BLITZ TECHNIQUE

But I would submit that the German failure in the Battle of Britain was the result of earlier misconceptions of the possibilities and limitations of air force, rather than a failure of the force itself. They did not design or plan correctly for that part of their conquest.

Action in Poland, Norway, Holland, and France indicated that the German blitz technique allowed no place for the slower process of internal decay which results from real strategic bombing. The classic one-two-three cadence was in her crushing blows directly against the enemy defenses, and her overwhelming superiority enabled her to drive through. She designed her airplanes with that in mind, and her initial success speaks for itself.

But the German concept of air force was too limited. It contemplated the use of airplanes for only three basic purposes: (*a*) To attack enemy surface forces at and near the line of contact; (*b*) to transport men and equipment, sometimes well behind enemy lines; (*c*) and to defend their own forces and territory from similar air operations of the enemy.

This worked beautifully until Germany tried to use the same weapon, one designed and trained for tactical use, in an all-out strategic attack upon a major nation. She visualized strategic bombing of Britain as being the same as the helter-skelter bombing and strafing of front-line forces. She thought that she would smother England under a rain of bombs so solidly that the traditional English will would be broken along with British industrial might. The idea was there, but the method was wrong.

As Mr. Churchill said, in effect, in a paper on air power written in 1917, nothing that we know about warfare can lead us to believe that bombing for terror alone can cause such a morale collapse as to force a major nation to sue for peace. He said that air power must single out and attack transportation, factories, and other enemy installations upon which the enemy war-making ability depends. England of 1943 is living proof of the truth of the first part of that statement, and the Allies are now proving the remainder.

But Germany obviously did not realize the full implications of Mr. Churchill's remarks. She did not visualize the singling out of industrial units as being a refined process. Certainly if she had been using super-long-range cannon to deliver the projectiles, German tacticians would have insisted, in the interest of efficiency, that the guns be aimed at specific factories, docks, and other vitals. Instead of visualizing the airplane and its bomb load as being finite quantities, she seemed to consider them as capable of covering England with a solid blanket of fire and explosive, thereby insuring the destruction of all British industrial vitals.

But even in the relatively small area of Britain, industry is not concentrated when we measure distance in terms of bombs

required for solid coverage by relatively unaimed bombs. The space occupied by a machine shop is very small compared to the space filled by the homes of the men required to operate the shop. Then, when we consider the immense additional city area having little if any connection with the machine shop, we begin to realize the reason why Hitler's blitz of cities by scatter-bombing failed to destroy the vitals or even to impair them very seriously.

That, of course, is said without any desire to detract from the magnificent defense put up by the outnumbered RAF. Only history can bring out the full glory of that small, heroic force. But we cannot get away from the fact that when strategy and efficiency called for precision, Germany bombed for terror with unaimed bombs and hoped in vain that chance would aid in hitting vital points.

PRECISION BOMBING AN AMERICAN AIR FORCES' CONCEPT

The lesson is now written in history for all to heed, but without making any pretense to omniscience, the Amercan Air Forces have long had that idea as a basis for their planning of equipment and technique. Efficiency expressed in the military maxim "economy of effort" is an epitome of the air concept upon which we have based all of our efforts, and this is best attained in strategic bombing by scientific target selection and precise placement of bombs where they will do the most real damage.

This demands a complete analysis of enemy industry to determine the relative importance of each type of industry and, then, the relative importance and vulnerability of each unit of the selected industries. Cities, as such, are not considered though many units of industry within a particular city may be singled out as requiring destruction.

Such an analysis results in the discovery that a relatively small percentage of the many hundreds of industrial units need be destroyed in order to ruin the enemy's ability to wage war on modern terms. But even then we cannot be prodigal with our force. If we were using cannon, as I said before, we certainly would aim carefully, and we cannot fail to realize that a bomb is essentially the same as a shell fired horizontally at the speed of the airplane. No matter what our potential wealth may be, we still must measure it in finite terms, and our weapons will always be counted in finite figures. Therefore, we must exert every effort to be as economical as conditions permit. Destroy the targets but do it efficiently with a minimum waste and in the shortest possible time. Precision bombing does this.

Aimed fire is considered essential in the infantry when individual soldiers may be armed with a nine-dollar 30-caliber rifle. We have paid bonuses for many years to encourage men to qualify as expert riflemen and sharpshooters. The necessity for precision bombing should be fully as obvious.

The enemy war machine—and it is a machine—is analogous to an automobile which we want to prevent from running. It is parked at the curb and entirely within our reach. Would we take an axe and start chopping and pounding until we beat it to a pulp? Or would we merely take out and hide the rotating contact in the ignition distributor?

Another analogy is in the old story that "for want of a nail, the battle was lost." We take away the nail.

More specifically, we might point out that, though we can stop a tank by killing its occupants, suffering casualties on our side while doing this, would it not be more economical to destroy the potential tank by taking away the lathe used in its construction? Strategic bombing has that for its initial objective.

COMPONENTS OF AN INTEGRATED AIR FORCE

Many volumes could be written about air power as we visualize it, but like sea power, it cannot be described within the limitations of any one of its phases. It must always be composed of separate types for various functions, each essential, if it is to fulfill its purpose. Fighters are necessary for defense and for attaining air superiority. Medium and light bombers are vital factors in direct support of surface forces, and the longer-range medium bombers also serve in the strategic effort farther to the enemy's rear. But air force reaches its peak expression in the heavy long-range bombers which are the only weapons capable of hitting the real sources of mechanized military power.

Properly employed, a well-integrated air force serves to decrease the time as well as the cost of the final victory in life and wealth. To determine the proper sequence of operations, let us attempt to visualize the ground-force requirements and potential losses involved in the invasion and final subjugation of the enemy.

A PATTERN FOR INVASION

With no strategic bombing, it is readily apparent that the initial ground-force requirement is very high. Statistics of the first world war show that casualties will also be very high. Killed, wounded, and missing involve nearly 50 per cent of those committed.

Before invading, let us start a scientific program of strategic bombing of enemy industry.

At first we will make shallow penetrations, striking primarily at targets which will reduce the air-defense power of the enemy—hitting aircraft factories, flying fields, and knocking down fighters.

Other targets on our schedule also will be hit, but there will be nothing spectacular about the process. Little or no effect will be seen in the front lines, and an invasion started during this period would require the same strength and experience the same losses, as if no strategic bombing had been done.

The second phase starts when we have gained the edge over the enemy's production of airplanes for defense, when he is no longer able to increase his defenses, and when we can stand the losses of deeper penetrations. Our bomber force must be larger here and steadily growing throughout this period which will end when the effectiveness of the enemy defenses is definitely on the downgrade.

Again, there will generally be but little evidence in the front lines of the real effect of strategic bombing. The internal decay will be well under way, but production is normally so far ahead of war use that only isolated evidences of shortages will be noticeable. Thus, during this period, there will be but little lowering of the ground-force requirements and losses in case of invasion.

Now we start the third phase in which we really get down to the business of knocking out the heart of enemy production capacity. But it is still not spectacular. A chemical plant shattered here, an airplane factory flattened there, and a synthetic-oil plant in flames. That is the sort of thing you see in the daily communiqués.

And if you looked down on the whole face of Europe as on a map, you would see little to attract attention. Tiny puffs of smoke and flame where precision bombing was doing its pinpointing of enemy vitals like a skillful surgeon removing a tumor from a vital organ. But in this case, the work is to create the cancer in the enemy vitals—to cause the internal decay— eventually leaving but a shell similar to a pie crust which crumbles away when punched even gently.

During this third phase we really begin to realize dividends. The effects of previous bombings will begin to be felt by front-line forces, so that an invasion started late in this period will require much less force and will experience considerably less loss. However, if time permits, it should not be attempted while there are prospects of further reducing forces required and losses to be expected.

The fourth and last phase starts when we have completed the initial destruction of the selected vitals and have started the cleaning-up process on items overlooked. We will also have to

destroy a few units which have been built from the ruins of earlier destruction, keeping a sharp watch to see that new sources are not left untouched.

No matter how long this finite bombing continues, it cannot completely eliminate the necessity for occupation and final subjugation, and there is a minimum force which must be used even if there is no opposition. Also, it is not possible to take away all of the arms which may be on hand and there will always be casualties in an invasion force.

The invasion should start when to delay longer would waste effort, but when its cost has been reduced to a minimum. Of course, it is not a matter of following a precise time table, but measured in months, it is almost so. Faith and understanding are the essential requisites—faith in the theory behind strategic bombing and understanding of its limitations and uses.

BASIC PRINCIPLES OF AMERICAN AIR-WAR DOCTRINE

In conclusion, we might point out certain special features of the American concept of air force, and particularly of our idea of strategic bombing, which tend to lift air power from the depths of Axis brutality.

In the first place, we hope and fully expect to prevent most of the enormous losses which would be suffered on our side without this bombing, a saving beside which the most severe air losses will be infinitesimal. Next, the result of precision is efficiency measured in economy of effort, allowing the forces available to accomplish the task with minimum waste and in the shortest possible time.

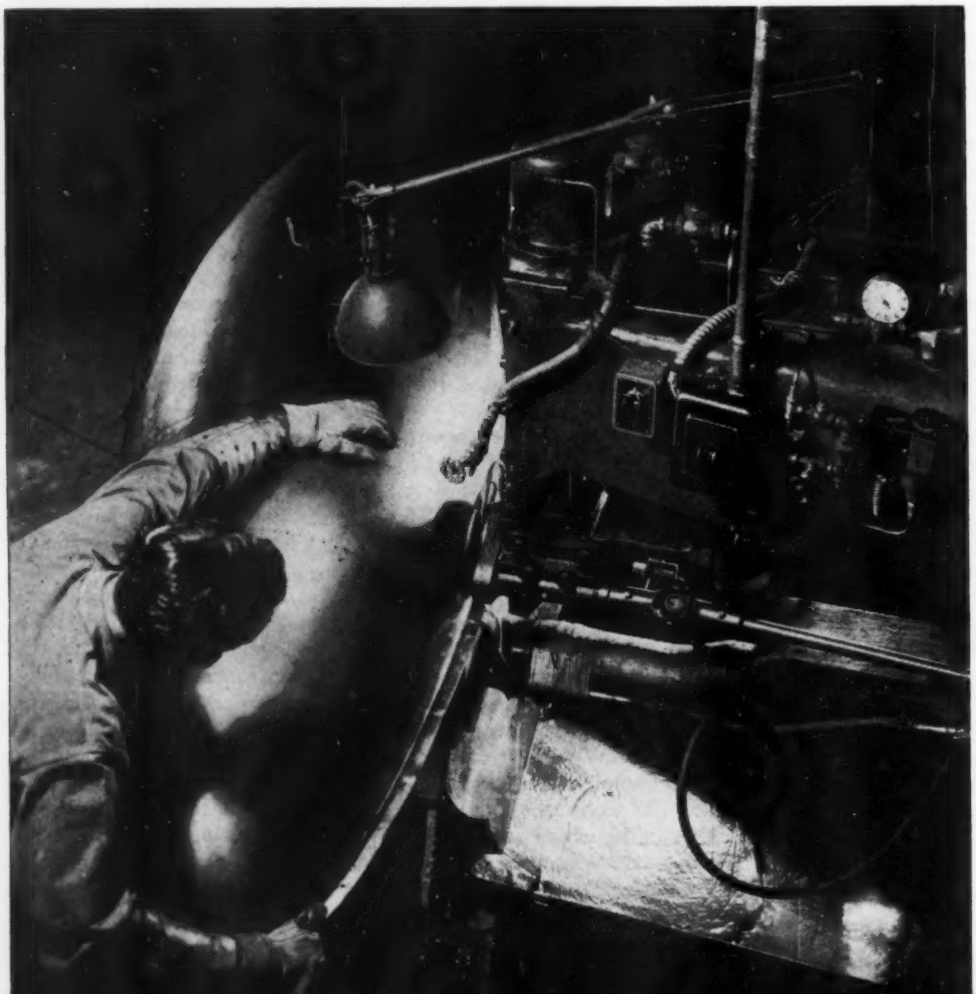
Another less tangible consideration, but one which cannot be ignored, is the postwar attitude of the nations toward each other. Bombing at its best cannot fail to cause some extraneous destruction and must certainly make the war and its hates very real to victim populations. Carelessness on our part would intensify and spread those hates which would be stumbling blocks to international peace for years after the actual fighting is over. Precision will hasten the time of new understanding.

Finally, we must recognize that postwar economy is intimately related to the manner in which bombing targets are selected and attacked. Due to the fact that modern communications have tied all peoples of the world as close to each other as were the original colonies from which this nation was formed, the standard of living of one nation must hereafter be definitely affected by that of any other. There must be a leveling off.

In order to prevent a serious reduction in our own standard, we must assist in the rebuilding of every other nation, enemy or ally. Therefore, aside from the necessity for economy of effort in winning the war, we have a very potent urge to defeat the enemy without causing any but the most unavoidable amount of extraneous destruction.

These are the basic principles of our air-war doctrines. Naturally they are the ideals, and due to human frailties and the elements of chance, we never attain the ideal.

By shooting for the maximum goal, we certainly will tend to approach it, and the Army Air Forces will never cease to exert itself along these lines. Efficiency and savings in the over-all cost in blood will be our constant objective.



DROPPABLE AIRPLANE GASOLINE TANKS "STITCHED" ELECTRONICALLY

(At the Lockheed plant near Los Angeles, droppable gasoline tanks for the *Lightning* P-38 are now being seam-welded by electronically controlled resistance welders, such as the one shown here, permitting the substitution of steel for war-scarce aluminum formerly used in these tanks. Equipped with precise General Electric electronic control which insures tough vibration-proof and gas-tight seams, this machine "stitches" two halves of the tank together at the rate of 60 in. per minute, taking only four minutes for the complete tank. Since no additional metal is deposited in this process, welding rod formerly used in torch welding is also saved. In use, two of the streamlined tanks are attached, like pontoons, to the *Lightning* P-38 and, when empty, may be dropped off to give the plane additional speed.)

Improving FATIGUE STRENGTH *of* MACHINE PARTS

By J. O. ALMEN

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WHILE great strides have been made in most phases of engineering and metallurgy, it is doubtful that, in dynamically loaded parts, we are getting more net work from our metals today than was obtainable a generation ago. The fact that our modern machines are generally lighter, cheaper, and more compact than the equivalent machines of a generation ago is primarily due to higher operating speeds, better understanding of commercial requirements, and reduced "factors of safety." New fabrication techniques have made possible many design improvements, better bearing materials are available, lubricants have been improved, but the basic useful strength of our structural materials remains unaltered.

Although no superstrength alloys have been discovered and no such discoveries seem to be imminent, there is much that can be done to increase materially the fatigue strength of many machine parts made from our ordinary structural materials. This fatigue strengthening does not require changes in design or in material, and in fact it does not require processes that are fundamentally new or untried. It is merely the extension of processes that, on the whole, have long and honorable histories and the avoidance of processes and practices that are now known to reduce fatigue strength. The significance of these processes has only recently become clear through the introduction of new concepts of fatigue phenomena by which new avenues of reasoning are opened to us. These new concepts are:

(1) Fatigue failures result only from tension stresses, never from compressive stresses

(2) Any surface, no matter how smoothly finished, is a stress raiser.

Fully 90 per cent of all fatigue failures occurring in service or during laboratory and road tests are traceable to design and production defects and only the remaining 10 per cent are primarily the responsibility of the metallurgist as defects in material, material specification, or heat-treatment. While this ratio is not a measure of the quality of workmanship contributed by each department, there can be no doubt that the metallurgist has a better appreciation of his responsibility for fatigue failures than has the designer, the engineer, or the man in the production department. In fact, this appreciation of responsibility by the metallurgist contributes to the relative irresponsibility of the engineer by overwillingness of the metallurgist to accept the blame when things go wrong.

Most readers are familiar with the routine that is followed when a failed part is received by the laboratory. The fracture is examined and is found to be due to fatigue, the material is analyzed for composition, sections are studied for all the many things that are metallurgically important, and a report is written describing the things that are and are not up to par. But no matter how many possible metallurgical causes of trouble are found, such examination is far from sufficient unless the failure is also examined for design faults and possibly bad fabrication and assembly practice. Most of the failed parts should not be sent to the metallurgist at all, but, unfortunately, very few engineers or production men are adequately trained in diagnosing fatigue trouble and, therefore, failures are seldom examined for contributing mechanical causes. Most of our engineers pass all fatigue problems on to the metallurgical department with the implication that something must be wrong with the material or with the heat-treatment. The metallurgist does his metallurgical best and, in the process, frequently destroys the evidence of mechanical faults.

The study of fatigue of materials is properly the joint duty of the metallurgical, engineering, and production departments. Unless all of these departments have an understanding of fatigue phenomena and the factors that promote fatigue, they cannot recognize their individual responsibilities for the product they manufacture. There is no definite line of demarcation between mechanical and metallurgical factors that contribute to fatigue and there must therefore be very close co-operation between the metallurgist and the engineering fatigue specialist, if such there is, or the metallurgist must possess the qualifications of the metallurgist, designer, and machinist. This overlapping of responsibility is not sufficiently understood in industry, and hence the engineers are constantly demanding new metallurgical miracles instead of correcting their own faults. It would be helpful if the metallurgists would be less willing to look for metallurgical causes of fatigue and insist that equally competent examination for mechanical causes be made. Until this is done, we cannot hope to make full use of engineering materials.

FATIGUE VULNERABILITY

The surfaces of repeatedly stressed specimens, no matter how perfectly they are finished, are much more vulnerable to fatigue than the deeper layers. It has long been appreciated that the vulnerability to fatigue increases as the surface roughness is increased, particularly if the roughness consists of sharp notches and more particularly if the notches are oriented at right angles to the principal stress.

The practice of carefully finishing fatigue-test specimens and engine parts is, of course, a recognition of this vulnerability in so far as visible marks or scratches are concerned, even down to assuring that the final polishing marks are parallel to the direction of the applied stress. These precautions are known to be effective in increasing the fatigue strength of the specimens; and specimens finished in this manner have therefore come to be known as "par" bars. This name implies that fatigue specimens and machine parts approaching perfection in finish give the highest possible fatigue endurance for any particular material and that they accurately measure the ultimate fatigue properties of that material.

It can be shown, however, that the so-called par bars are not the best specimens, but that influences akin to notches, in so far as fatigue vulnerability is concerned, are retained by the par specimens. It seems that the specimen surface is highly vulnerable simply because it is a surface; that there is an extra hazard in the surface layer not shared by the deeper layers. This extra surface hazard may be due to submicroscopic-notch effects or to the fact that the surface is a discontinuity since the outer crystals are not supported on their outer faces. What-

Presented at the 27th Annual Meeting, American Gear Manufacturers' Association, Rye, N. Y., May 17–18, 1943.

NOTE: Statements and opinions expressed in this paper are to be understood as those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers' Association.

ever the reason for a surface vulnerability, the evidence of its existence is strong.

FATIGUE LIFE INCREASED

The fatigue strength of the most carefully prepared specimen will be increased if a thin layer of the specimen is prestressed in compression (1)[1] by a peening operation such as peen hammering, swaging, shotblasting or tumbling, or by pressure operations by balls or rollers. This increase in fatigue strength resulting from the surface layer being stressed in compression is clearly shown by the S-N curves, Fig. 1, which compare nor-

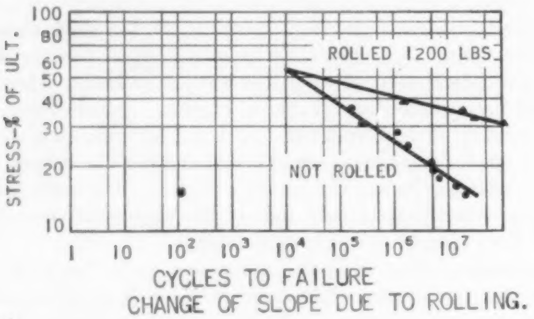


FIG. 1 COMPARISON OF NORMALLY FINISHED RAILWAY AXLES WITH AXLES UNDERGOING ROLLING OPERATION

FIG. 2 BENEFITS OF SURFACE-PEENING BASED ON FATIGUE LIFE

mally finished railway axles with axles that had been subjected to a rolling operation (2). This and many other tests show that the compressive-stressed surface is effective in increasing the fatigue strength, whether applied to highly finished specimens or to specimens having rough surfaces.

We are familiar with the improvement in fatigue that may be obtained by a few cycles of overload sufficient to produce a "set" in such parts as springs. Local tension stresses from the overloads exceed the elastic limit of the material, and therefore the tension stress at the working load is decreased. This treatment, which has long been practiced on many production items, is similar in effect to rolling or peening since, in the unloaded state, the member is stressed in compression in the areas where yield occurred during the overloading.

The bar chart, Fig. 2, records the increased fatigue durability resulting from shot-peening of a few typical machine parts. It will be seen that the fatigue durability is increased whether the parts are hard such as carburized gears, or soft such as steering-gear parts, and whether the stress is completely reversed as in crankshafts or the stress range is small as in preloaded springs.

Note that the fatigue durability of peened axle shafts was not increased as much as most of the other specimens. The work on these shafts was conducted a number of years ago before the technique of peening machine parts had been developed and the relatively small increase was probably due to insufficient peening. Similar fatigue results have been obtained from a large variety of machine parts and from aluminum specimens, and there are reasons to expect that the treatment is equally effective for all metals.

The bar chart, Fig. 2, shows the fatigue durability increase as percentage gain above the durability of the same machine part before peening. Actually, durability comparisons cannot be made on the percentage basis alone as is apparent when we examine the improvement in fatigue due to rolling as shown in Fig. 1. If in this chart, the durability comparison is made at a load equal to 55 per cent of the ultimate strength, the percentage improvement is zero, if the durability comparison is made at a load corresponding to 20 per cent of the ultimate strength, the percentage improvement is infinite and, at intermediate loads, the percentage gain will, of course, be somewhere between these limits.

It is essential that this be kept in mind when interpreting the fatigue data. To illustrate, suppose that the average fatigue durability of a gear tested at high load is increased from 30,000 cycles to 70,000 cycles by suitable surface peening, a gain of 130 per cent. Now if this comparison is made at a lower load such as to cause initial failure at 300,000 cycles, the treated gear might run 6,000,000 cycles before failure, a gain of possibly 2000 per cent. This is because of the difference in slope of the fatigue curve representing the normal gears and the fatigue curve representing the peened gears.

EXPLANATION OF PEENING EFFECTIVENESS

The most plausible explanation of the effectiveness of surface compression stress (3) is that when a load is applied to such specimens the tension stress in the surface layer is less by the

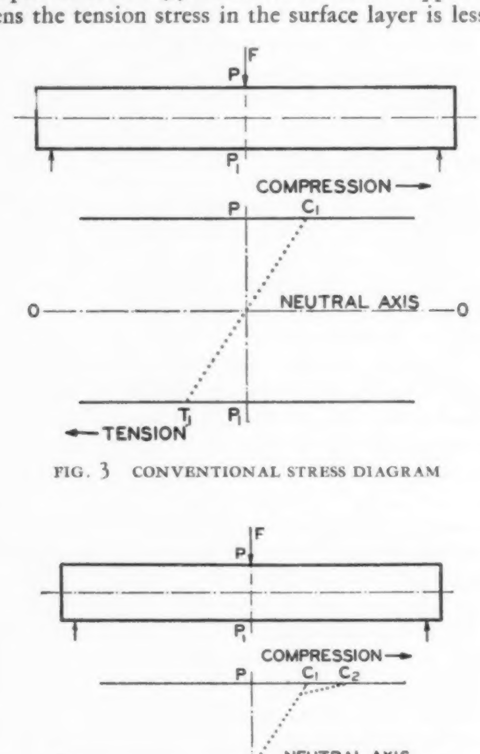


FIG. 3 CONVENTIONAL STRESS DIAGRAM

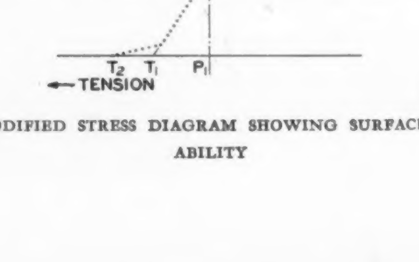


FIG. 4 MODIFIED STRESS DIAGRAM SHOWING SURFACE VULNERABILITY

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

amount of the compression prestress and since fatigue failure starts from tension stress the fatigue durability of the weak surface layer is increased. However, the tension stress in the material below the prestressed layer is not reduced but may be actually increased, notwithstanding which the fatigue strength of the specimen is increased. It follows, therefore, that the lower layer is inherently stronger than the surface layer.

Föppl (4) shows that the fracture in rolled specimens does not originate at the surface but in the material below the prestressed layer as would be expected if the surface is sufficiently prestressed in compression. Similar subsurface fatigue failures, usually called fissures and attributed to faulty material, have long been known to occur in railroad rail in which the surface is stressed in compression as a result of the cold work of heavily loaded locomotive and car wheels.

The situation can perhaps be clarified by the use of the conventional textbook stress diagram of a loaded beam, as illustrated in Fig. 3, in which a beam supported at the ends is loaded in the central plane, P, P_1. The stress at any point in the beam is measured by the horizontal distance from the plane P, in which the load is applied, to the diagonal line T_1C_1. The distance PC_1 represents the compressive stress at the upper surface, the stress at the neutral axis OO is zero, and the tension at the lower surface is represented by the distance T_1P_1.

While this is a satisfactory enough stress diagram for static loads, it does not agree with the behavior of fatigue specimens. However, if we modify the diagram Fig. 3 as is shown in Fig. 4, in which T_1T_2 represents an added increment of tension stress in the surface, we have a reasonable representation of the surface fatigue vulnerability. For a sharply notched surface, the additional stress increment T_1T_2 is relatively great. As the surface roughness is decreased the increment T_1T_2 decreases, but no matter how well polished the specimen may be, there still remains an additional surface stress as measured by fatigue tests.

STRESS PATTERNS

Fig. 5 represents the residual-stress pattern in an unloaded beam that has been rolled or peened, as has been described, in which C_3P and C'_3P' represent the magnitude of compressive prestresses and T_3A represents the magnitude of the tension prestress to balance the compression stresses in the surface. After this beam has been loaded from either side through 1 stress cycle, as in a reversed fatigue test, the compression prestress will be reduced if the applied load raises the total compression stress above the yield point. The stress diagram for such a prestressed beam supporting an external load is shown in Fig. 6 in which the effective tension stress T_4 at the surface may be less than the stress T_5 below the surface, in which case failure would start below the surface as noted by Föppl. Note also that the neutral axis is displaced from the geometric center of the beam and that the tension stress T_5 below the surface is greater than in the beam that had not been prestressed, as is shown by the dotted lines.

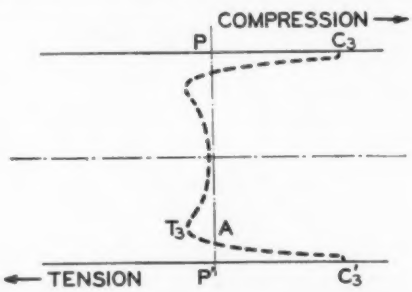


FIG. 5 PROBABLE STRESS DIAGRAM, BEAM WITH PRESTRESSED SURFACES (UNLOADED)

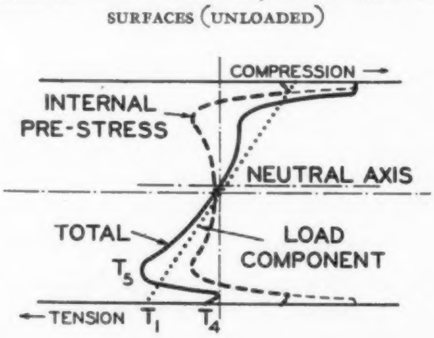


FIG. 6 STRESS DIAGRAM FOR A LOADED PRESTRESSED BEAM

The magnitude of the subsurface tension stress in a loaded beam having prestressed surfaces will vary with the amount of compression prestress and with the depth of the prestressed layer. Fig. 7 shows that the subsurface tension stress may be greater for a deeply prestressed layer than for a layer of lesser depth.

It seems evident that the improvement in fatigue strength

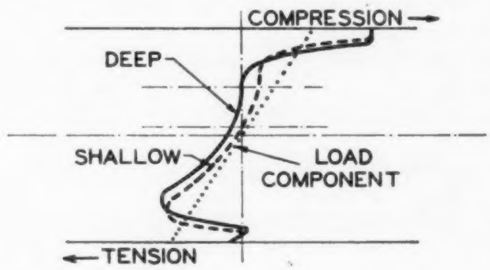


FIG. 7 DIAGRAM SHOWING INFLUENCE OF DEPTH OF PRESTRESSED LAYER

by compressive prestress is due to the reduction in tension stress when loaded in the vulnerable surface layer and that the increased compressive stress in a specimen stressed from zero to a maximum in either direction does no harm, probably because of adjustment of compression stress in the prestressed layer through yield.

Further evidence of the extra vulnerability of the surface layer is found in the behavior of specimens having increased strength in a thin surface layer, as in thinly carburized or cyanided specimens, or in thinly nitrided specimens. Fatigue failures in such specimens also start below the surface and show greater fatigue strength than the same material in the unclad state. A nitrided specimen is probably superior to the other forms of hard cladding because, in addition to the higher physical properties of the surface layer, this layer is in a state of compression and it is therefore less notch-sensitive.

RESIDUAL THERMAL STRESSES

While on the subject of beneficial internal stresses, mention should be made of surface compressive stress obtainable by heat-treatment. By a rapid quench, it is possible, through thermal contraction alone, to trap compressive stress in the surface and corresponding tension stress in the core, but this method, although showing some benefit in fatigue, is not so effective as the other methods that have been discussed. This subject will be discussed later in this paper.

Perhaps the most spectacular use of surface compression stress by heat-treatment through thermal contraction alone is tempered glass which, because of its great strength, is used in some parts of modern automobiles. This glass is prepared from normal glass by cooling the surfaces rapidly by means of air jets. The cooled surfaces contract causing the relatively plastic center to yield in compression. As the center of the glass cools and contracts, it becomes stressed in tension with consequent compressive stress in the surfaces.

FIRST USE OF SURFACE COMPRESSION

The idea of surface compression to improve the strength of steel is probably as old as steel itself. It has probably been

discovered, forgotten, and rediscovered many times. Certainly every village blacksmith knew and practiced the art of making wagon and buggy springs, axles, and other heavily loaded parts. After these parts were forged into shape they were severely hammered to improve their strength, and no doubt the same procedure was followed by the ancient sword makers. Likewise, mill and ship shafts were cold-worked by the application of small rollers at high pressure after machining because of the greater strength that was known to result.

Cold-working of metals increases the hardness of most metals including steel, at least in the range of low hardness; it usually results in internal stresses of varying degrees and patterns; it alters the physical properties, and sometimes fractures the material. With the known sensitivity of materials to fatigue, it is obvious that we must learn how to control cold work just as we have had to learn how to control heat-treatment in order that we may benefit by the good effects and overcome the evil effects. We would not think of specifying a heat-treatment without stating whether the temperature should be raised or lowered and in which order and to what extent; yet that is the way we now think of cold work. Cold working can be good or bad, depending upon how it is done and for what purpose.

PRESTRESSING MAY BE OVERDONE

Papers have been published showing that cold-working of the surface so as to produce a layer stressed in compression increases the fatigue strength of the parts to which it is applied, but we are not told the amount of the prestress or the depth of the prestressed layer. Both of these values are presumably important in obtaining optimum results for any particular specimen but it is probable that the value should not be the same for all sizes of specimens, for all materials, or for hard and for soft specimens.

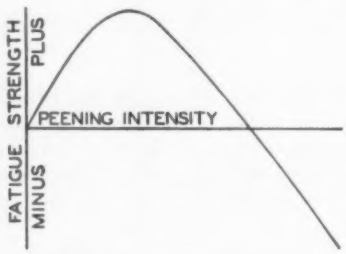


FIG. 8 EFFECT OF PEENING INTENSITY ON FATIGUE LIFE

Several instances are known in which the strength of machine parts and specimens has been decreased by too intense surface peening. Fig. 8 is presented as showing the probable effect of peening or rolling particularly on thin sections. The fatigue strength is increased as the intensity of peening or rolling is increased until a maximum improvement is obtained. With more intense peening or rolling the fatigue strength rapidly decreases below the original strength and the part will be damaged because of excessive internal tension stresses.

It would therefore seem important to control the compression-stressed layer, as to stress magnitude and depth, with considerable accuracy by proper selection of the curvature of the rolling or peening instruments and by the pressure that is applied. The precise amount of surface compressive stress that is required for optimum fatigue strength is known for a few specimens only. It will vary with the shape and section thickness of the machine part, with the hardness and with the kind of metal being treated. For the present, we must frequently rely upon the not too accurate sense of proportion that is developed by experience to indicate the treatment that should be applied to any given machine part.

When the layer is stressed in compression (by applying sufficient pressure on the work by rollers or by peening) to a degree exceeding the yield strength of the metal in compression, the amount of residual stress is presumably at least equal to this yield strength.

The depth of the stressed layer is probably roughly proportional to the instantaneous area over which the pressure is applied, and to the pressure intensity. The depth of the compression-stressed layer in a railroad rail (5) should be greater than the depth of the compression-stressed layer in the same material if small rollers at the same pressure intensity were used instead of large car wheels. Under these circumstances, the initial point of fracture should appear at corresponding depths. Such evidence as is available indicates this to be true.

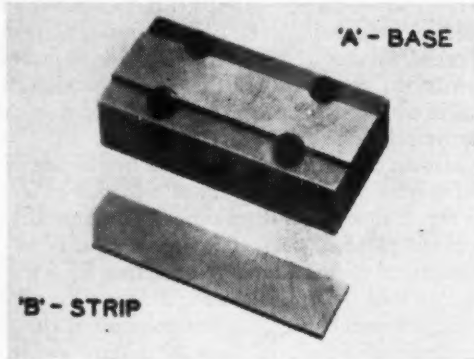


FIG. 9 APPARATUS FOR MEASURING COMPRESSION-STRESSED LAYER
(*a*, Base; *b*, strip.)

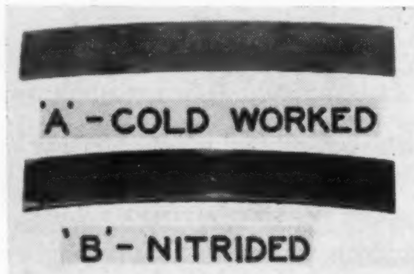


FIG. 10 MEASURING STRIPS
(*a*, Cold-worked; *b*, nitrided.)

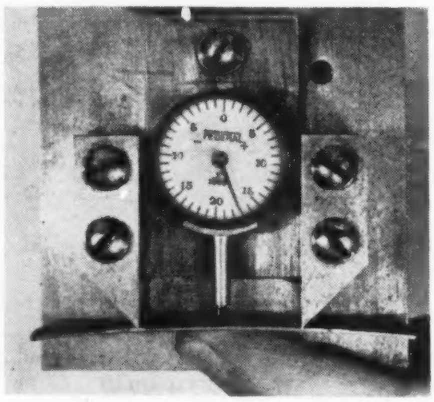


FIG. 11 CURVATURE INDICATOR

INSTRUMENT MEASURES PEENING

A simple and practical method for indicating the compression in the stressed layer consists of a thin flat strip, Fig. 9(*b*), that is attached to a heavy base Fig. 9(*a*). This strip is rolled or peened with the same intensity that is given to the

machine part and when it is removed from the base it will be found to be curved as in Fig. 10(*a*) with the convex surface on the cold-worked side. The curvature of the strip may be measured by an indicator, shown in Fig. 11, which can then be interpreted in terms of the depth of the stressed layer.

The chart, Fig. 12, records the stress magnitude and the depth of the stressed layer at constant cold-work intensity of two such test strips. The cold-worked surfaces of these strips, the Rockwell C hardness being respectively 64 and 40, were honed away in small increments and the curvature was measured with the removal of each thin layer. The changing curvature as metal was removed provided data from which the compressive stress in each layer could be calculated with the results shown in the chart. As would be expected, because of the higher yield point, the harder specimen was found to be more highly stressed than the softer specimen.

Also shown in this chart is the surface compressive stress in a nitrided specimen as a result of the nitriding. The procedure for this experiment was the same as for measuring the stress due to peening except that the face of the specimen that was in contact with the heavy base was plated to limit the nitriding

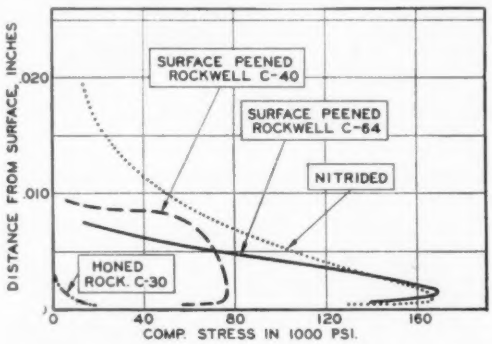


FIG. 12 STRESS IMPOSED BY VARIOUS SURFACE TREATMENTS

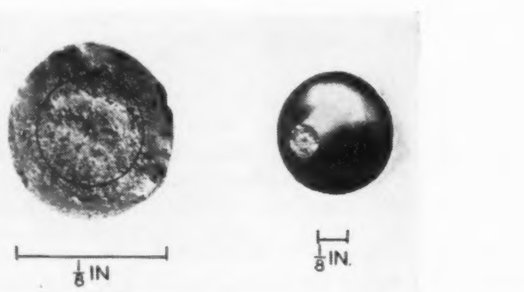


FIG. 13 FAILURE FROM SEVERE TENSION STRESS RESULTING FROM DEEP NITRIDING

to the outer face of the strip. On removal from the base after nitriding, the strip was curved convex on the nitrided side as is shown in Fig. 10(*b*). It seems therefore that the well-known resistance of nitrided specimens to fatigue is primarily due to the compressively stressed surface layer.

OVERDOSE OF NITRIDING

Although the usual experience with nitriding is that it greatly improves fatigue strength, it is possible to overdo nitriding just as it is possible to overdo surface stressing by peening and rolling. The high compressive surface stress that results from nitriding must, or course, be balanced by internal tension stress of equal total value. When deep nitriding is applied to light sections the unit internal tension stress may reach dangerous proportions.

Fig. 13 shows a part that was greatly reduced in strength as a result of nitriding, its fatigue durability being only 1 or 2 per cent as great as the fatigue durability of the same part not nitrided. The diameter of the part at the point of failure was approximately $^1/_8$ in. The depth of the nitrided layer was about 0.020 in., the area of which is equal to 60 per cent of the area of the section, as is shown by the circle in the enlarged view. From the nitriding compressive stress diagram, shown in Fig. 12, it is evident that the internal tension stress must have been very great.

It is also known that internally nitrided cylinder barrels are more prone to fail by cracking than cylinder barrels that are not nitrided, the reason being that the stress due to nitriding is added to the stress from gas pressure. Care must therefore be used in nitriding thin sections to gage the depth of the nitrided layer in proportion to thickness of the section being nitrided.

RESIDUAL STRESS FROM HONING

While the peened specimens used for the experiment, Fig. 12, were being honed as has been described, it was found that the

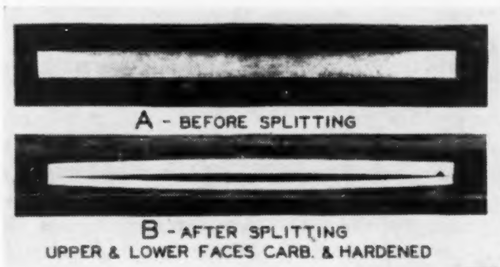


FIG. 14 RESIDUAL STRESS RESULTING FROM CARBURIZING AND HARDENING

(*a*, Before splitting; *b*, after splitting. Upper and lower faces carburized and hardened.)

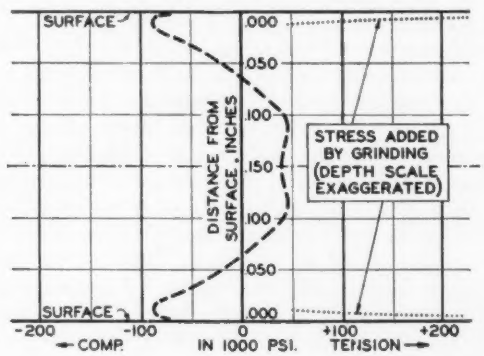


FIG. 15 RESIDUAL STRESS DUE TO CARBURIZING AND HARDENING

strips did not fully recover their original flat form. To determine if this residual curvature was due to a "set" in the material or was the result of honing, other flat strips that had not been peened were honed. These strips developed the same curvature as the residual curvature in the peened specimens demonstrating that honing produces a compressively stressed layer. The approximate magnitude of this honing stress is also shown in the chart, Fig. 12. This raises a question as to the state of surface stress in the carefully prepared fatigue specimens favored for laboratory fatigue tests, since additional tests have shown that lapping also introduces surface compressive stress.

RESIDUAL STRESS FROM CARBURIZING

The carburized layer in a carburized part is stressed in compression, as is graphically shown in Fig. 14. Two opposite faces of this $^1/_2$-in-square specimen were carburized while the other two faces were protected by copper-plating. The specimen was quenched and tempered in the usual manner, after which it was split with a saw, as shown in Fig. 14(*b*). Note

that the parts are curved convex on the outer faces indicating compressive stress in these faces. Analysis of the internal stresses in another carburized member by a method similar to that described for peened and nitrided strips indicated the internal stress pattern shown in Fig. 15. Of interest here is the magnitude of the compressive stress in the carburized layer and the reduced compressive stress, possibly even tension stress, in a thin surface layer. When carburized parts such as bearing races, wrist pins, and gear teeth are ground we may expect the surface to be stressed in tension, as is indicated by the dotted lines shown at the right in Fig. 15.

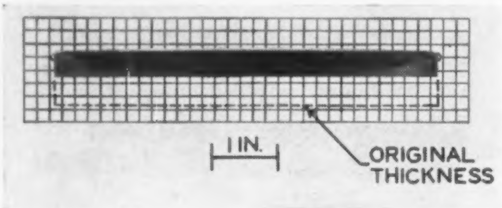


FIG. 16 INTERNAL STRESSES FROM INDUCTION HARDENING

The compressive stress in the carburized layer may be a hazard for members stressed in tension as was shown for the nitrided part, Fig. 13, because the tension stress in the core is equal to the working load plus the tension load due to the compressive preload of the case. For members stressed in bending and in torsion, however, the internal compressive stress in the carburized case of ordinary depth improves the fatigue strength of the part, except for the thin surface layer which, especially after grinding, is severely stressed in tension. It is, however, a simple matter to convert this thin tension-stressed layer into stress in compression by suitable peening or rolling operations, as indicated in Fig. 12, with resultant large gains in bending and torsion fatigue strength.

The residual stress in crankshafts and other parts hardened by induction heating and probably also in flame-hardened parts resembles the residual stress in carburized and hardened parts, as shown in Fig. 16. The hardened upper surface of this specimen was straight at the original thickness. Note that after removal of the material indicated by the dotted line, the upper surface is curved convex, indicating compressive stress. More complete analysis indicated that a thin surface (upper) layer was possibly stressed in tension. In these treatments, as in carburizing, the hardened layer is stressed in compression because in undergoing the phase change to the hard state the density of the steel is reduced, and therefore the hardened layer seeks to occupy more space. A thin surface layer, however, may be stressed in tension.

With internal stresses of the magnitude shown in Fig. 15, we can readily understand why carburized parts are prone to warp during heat-treatment especially if the design is not symmetrical with respect to the internal stresses.

LOW TEMPERATURE QUENCHING STRESSES

Residual stresses due to quenching from relatively low temperatures may reach considerable magnitudes and may be harmful or helpful to fatigue durability depending upon whether the trapped stresses augment or diminish the tension stresses from the applied loads. An interesting case of this kind occurred in a water-cooled aluminum cylinder head, Fig. 17, that failed by fatigue on the water side of the combustion-chamber wall. Measurements of residual stress disclosed that the water side of the combustion-chamber wall was stressed in tension and the combustion-chamber side of the wall was stressed in compression. This internal stress pattern was one of the same kind as the stress from the gas pressure against the combustion-chamber wall, and the resultant stress was therefore the sum total of the residual stress and the gas pressure stress.

The residual stresses in this case were caused by quenching the cylinder heads from 980 F by immersion in cold water. The outer surfaces of the casting were cooled while the inner water-jacket surfaces, especially at the thick section, were still hot. Thermal contraction of the outer surfaces imposed compressive stresses of such magnitude as to cause yield in the still hot and therefore weaker water-jacket surface. As cooling progressed, the metal that had been stressed beyond the yield point contracted thermally leaving tension stress on the water jacket side and the corresponding compression stress on the combustion-chamber side. The retention of the residual stress in the thick combustion-chamber wall was aided by the thinner outer wall of the water jacket which was stressed in compression.

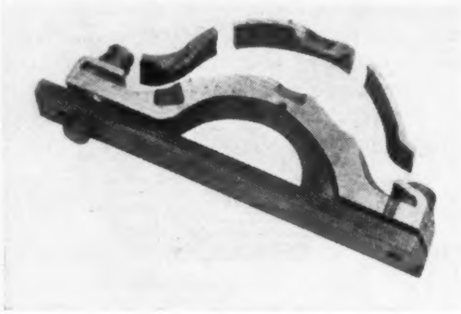


FIG. 17 METHOD OF INDICATING QUENCHING STRESSES

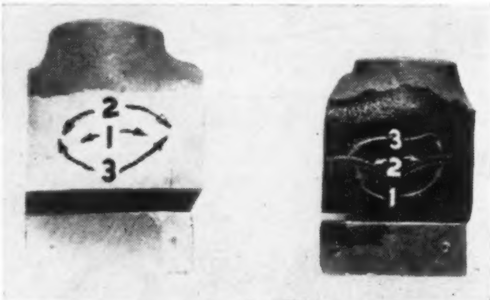


FIG. 18 VARIATION IN INTERNAL STRESSES FROM DIFFERENT QUENCHING METHODS

(Left, externally quenched; right, internally quenched.)

A visual indication of the residual stress pattern is shown by the scribed arcs at the left in Fig. 18. These arcs were drawn from centers in a steel bar bolted to the opposite side of the casting section, as shown in Fig. 17. The arcs indicated by the numeral 1, Fig. 18, were drawn when the cylinder head was intact. The casting was then sectioned, as shown in Fig. 17, except that the outer side of the water jacket had not been cut and the arcs indicated by the numeral 2 of the same radius as before were drawn. Finally the outer side of the water jacket was removed and the arcs indicated by the numeral 3, still of the same radius, were drawn. Note the direction of movement of the metal with each operation and the order of the stress that is indicated.

As a correction of the undesirable residual stress shown by this test, another cylinder head was given the same heat-treatment except that it was quenched internally by forcing cold water through the water jacket. The order of internal stresses was measured in the same manner as has been described with the results shown at the right in Fig. 18. Note that when internally quenched, the stress pattern in the combustion-chamber wall is reversed, leaving the inner side in compression and the outer side in tension. Since these trapped stresses are of opposite sign to the operating stress the resultant stress is the difference between the residual and operating stresses in-

stead of their sum as when the casting was quenched externally.

FATIGUE LIFE INCREASED

Fatigue tests were conducted on cylinder heads quenched by both methods, the results of which were 2,000,000 to 3,000,000 stress cycles to failure for the externally quenched heads and 5,000,000 to 6,000,000 stress cycles for the internally quenched heads.

Additional fatigue tests were made on internally quenched heads in which the aging treatment at 350 F was omitted in order to avoid reduction of the favorable stress pattern. These heads endured more than 14,000,000 stress cycles at the same test load without failure.

Similar residual stresses are known to occur in many other heat-treated and quenched aluminum parts. It is also known that many aluminum parts show better fatigue resistance when they are drawn to a higher temperature than that which gives the greatest tensile strength, presumably because unfavorable residual stresses resulting from quenching are thereby reduced. It is probable that similar stresses can be trapped in steel by quenching from tempering temperatures (6). Such residual stresses may be favorable or unfavorable depending upon the shape of the part, the temperature gradient, and the direction of heat flow.

CORROSION PROMOTES FATIGUE

Fatigue failures in many machine parts are traceable to corrosion of several kinds or to other forms of surface damage that occur in service. In normal machine parts even slight corrosion or bruising is very potent in encouraging fatigue fractures because each pit interrupts the continuity of the surface and increases the local stress. The damaging effect of corrosion or bruising is prevented on the surfaces that are adequately protected by compressive prestress because the local tension stress cannot reach dangerous values until the pits or bruises have progressed sufficiently to penetrate the compressively stressed layer. This was forcefully demonstrated in fatigue tests of a machine part that failed alternately in a badly formed fillet or in the region of a clamp remote from the fillet where fretting corrosion occurred. The durability of the part could not be increased by improving the fillet because this would merely transfer all failures to the fretted area at about the same durability. After peening, however, the fatigue durability was found to have increased several hundred per cent and large additional gains were then possible by improving the form of the fillet without failure in the corroded area. The peening did not prevent corrosion but it did prevent the ill effect of corrosion in promoting fatigue.

Similar protection against the effects of corrosion and of surface bruises is afforded by nitriding (7), carburizing, and other treatments that produce compressively stressed surfaces. The working face of a gear tooth may be severely pitted, creating a fatigue hazard, but the bending fatigue strength may not be impaired because the carburized layer is compressively stressed and the surface is compressively stressed by the cold work of mating teeth.

SURFACE FINISHES

Efforts to improve products by improving surface finish may sometimes have the opposite effect. Highly finished surfaces and fillets may lead to a false sense of security if, as the result of machining or straightening operations, the parts have high internal stresses of the wrong kind.

When machine-polishing is done by the use of abrasive paper or cloth wheels, or abrasive-covered felt wheels, sufficient heat is often generated to induce serious surface tension stresses, thus promoting instead of preventing fatigue failures.

In ground surfaces such as shafts, wrist pins, and gear teeth, the grinding operations may introduce high surface tension stresses that from the standpoint of fatigue strength often do more harm than good. The surface tension stresses from grinding are often so great as to produce visible or magnaflux surface cracks but whether detectable or not, surface tension is frequently very serious.

Fig. 19 reproduces a magnaflux transfer print on transparent cellulose tape showing surface fractures in a ground gear tooth. This tooth failed by spalling originating in these surface fractures. Since fatigue cracks start on the side of the gear tooth that is loaded in tension, the effective stress is the grinding prestress plus the working stress. Frequently we find that a hardened part will show a file-soft skin after grinding which not only promotes fatigue but is also susceptible to seizure and galling.

Internal stresses of the wrong kind are perhaps the most insidious of all fatigue hazards because we can seldom know their magnitude or the pattern in which they are distributed within the material, or whether they are alike for all commercially identical machine parts. Internal stresses may be the result of operating conditions such as occur in brake drums, clutch

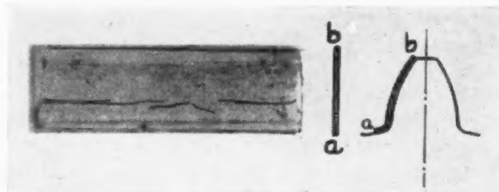


FIG. 19 SURFACE FRACTURES RESULTING FROM GRINDING

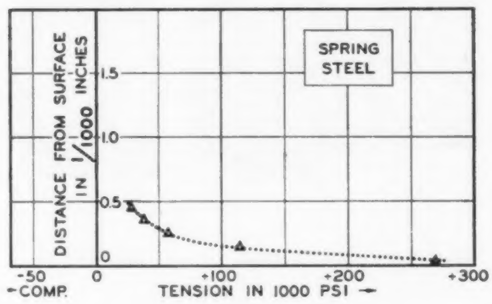


FIG. 20 RESIDUAL STRESS CAUSED BY GRINDING

plates, or other friction surfaces where the instantaneous temperature in a thin layer is so great that, under thermal expansion, the surface layer is stressed beyond the yield point in compression. When the source of heat is removed, the heated surface layer is quenched by the adjacent cool metal, and under thermal contraction it is so severely stressed in tension that fractures often occur. This is, of course, the same thing that happens in machine-polishing and in grinding unless great care is used.

The magnitude of surface tension stress in a specimen that was ground in accordance with normal commercial practice is shown in Fig. 20. A specimen of annealed spring stock $^1/_{16}$ in. thick, 1 in. wide, and 7 in. long was ground to a depth of 0.002 in. After grinding, the previously straight specimen was found to be curved concave on the ground side indicating tension stress. Very thin layers were then removed from the ground surface by hand honing until the specimen regained its initial straightness. Measurements of the change in curvature with each thin layer removed permitted calculation of the stress distribution, as is shown in the chart. Surface stresses of this magnitude are not unusual in the ground production parts, but we are seldom aware of their pressure unless actual failure has occurred.

Obviously, a stress of 270,000 psi, a stress just below fracture point of full hard steel, could not be supported by the

steel in the annealed state, from which it follows that the stress layer was hardened by the heat cycle of the grinding operation to not less than Rockwell C 55. The extreme thinness of the hardened layer presents an interesting problem in hardness measurement as is shown in Table 1.

TABLE 1 MEASUREMENTS OF HARDENED LAYER

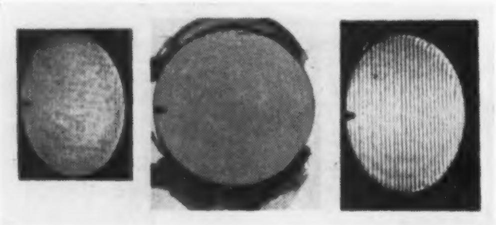
	Unground	Ground
Rockwell B	88	89
Rockwell C	5	5
Vickers Brinell	193	199

This table demonstrates the futility of our normal hardness-measuring technique for measuring the hardness of the most significant portion of our machine parts, the surface layer.

Internal stresses often result from the cooling of castings and forgings or from the vigorous heat transfer of heat-treating. Many parts such as crankshafts, axle shafts, and camshafts require straightening during processing. Since the straightening operation is usually done at room temperature and, since the part is rarely stress-relieved after straightening, the result is severe internal stresses.

MACHINING DAMAGE

In turning, milling, and other machine operations, it is necessary that metal be removed at a minimum cost, and therefore the cutting tools must often take deep cuts at high feed rates. Since metal cutting is more accurately described as a metal-tearing operation, in so far as stresses are concerned,



(a) Machined (b) Lapped (c) Shotblasted

FIG. 21 MACHINING DAMAGE

we need not be surprised to find serious internal stresses to considerable depths after machining. When metal cutting has been unusually severe or after operations such as punching and shearing, we often find that the surfaces are actually fractured. Finish-machining or grinding rarely goes deep enough to remove the internally stressed metal from previous rough-machining, and of course these finishing operations add stresses of their own. Whenever it is economically practicable, internal stresses that produce tension in any surface layer subjected to cyclic tension stress should be reduced or removed or, better still, converted to compressive stress by suitable treatment because all fatigue failures are due to tension stresses.

In connection with machining damage, an interesting and perhaps important observation has recently been made which indicates that the layer "injured" by machining is deeper than is generally believed. It also shows that the "injured" material does not recover by heating for long periods at high temperatures. Fig. 21(*a*) shows a bar of No. 4615 steel as it appeared after rough-machining on a shaper. This piece was then carburized for 8 hr at 1700 F, cooled in the box, reheated to 1500 F, quenched in oil, and drawn at 300 F for 1 hr. The machined surface was then ground in a direction at right angles to the shaper marks to a depth of 0.0055 in. below the last visible tool mark, after which it was polished, as shown in Fig. 21(*b*). Finally, the polished surface was shotblasted, whereupon the machining marks (vertical lines) and the grinder marks (horizontal lines) reappeared as shown in Fig. 21(*c*), showing that the material is not uniform in resisting the shotblasting notwithstanding the long period at elevated temperature. There is no evidence at present that the effect brought out by this experiment is significant in fatigue. It is presented here merely to emphasize that there is much that is not known about our materials and processes.

MATERIALS ARE ELASTIC

A common cause of fatigue vulnerability is the belief apparently held by many designers and engineers that our structural materials are rigid. Many fatigue failures can be traced to elastic deflection for which no allowance was made in the design. Elastic deformation of mating parts may be such as to concentrate the load in a small region as often occurs under operating conditions.

Under operating conditions a crankshaft may be so elastically deformed in twisting and in bending that the bearings are only partially effective in supporting the load. The bearings are frequently found to be plastically deformed or worn "bellmouthed" to accommodate the elastic gyrations of the crankshaft.

Perhaps the most generally misunderstood of all machine elements are the several classifications of gears. As ordinarily designed there is only one thing certain about gears and that is that they will not function as intended by the designer. When laying out a set of gears on the drafting board, the mating gear teeth are represented by parallel straight lines over which the load is assumed to be uniformly distributed, but no matter how carefully the gears are cut and heat-treated, the mating teeth will never again be parallel except by accident and then only through a small load range.

The nature of the contact between two mating gear teeth is influenced by the following:

1 The elastic characteristics of the housing in which they are contained.

2 The elastic characteristics of bearings by which they are supported.

3 The elastic characteristics of the shafts upon which they are mounted.

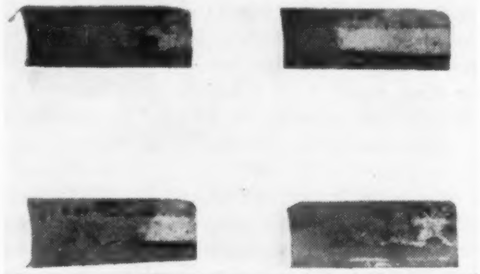


FIG. 22 GEAR CONTACT IMPRESSIONS

4 The elastic characteristics of the gears themselves.

5 The accumulated dimensional errors in all the supporting parts as well as the errors in the cutting of the gears.

6 The necessary and accidental clearances in the supporting parts.

7 Misalignment of supporting parts through thermal expansion.

8 The amount and nature of the warpage in heat-treating to give the metallurgist some of the responsibility.

The result of all this is that it is virtually impossible for the parallelism between mating teeth, as visioned by the designer, to exist in practice. If it should chance that two mating gear teeth are parallel at some load, they cannot be parallel at any other load because the elastic deflections of some of the sup-

porting parts are not linear with respect to the load. As ordinarily designed the load on gear teeth is never uniformly distributed over the length of the teeth but is always concentrated toward one end of the teeth. This localization of the load is shown in Fig. 22, which is a record of the contact impressions of gear teeth under load in a commercial gearbox.

Load localization cannot often be seen by examination of a gear that has been serviced because usually each tooth of each gear makes contact with all of the teeth in the mating gear, and therefore the summation of all contacts under all load conditions will be seen by the examiner.

LOCALIZED GEAR-TOOTH LOAD

Fig. 23(*a*) shows a gear that failed in service. This gear was "rescued" while on its way to the metallurgical department to

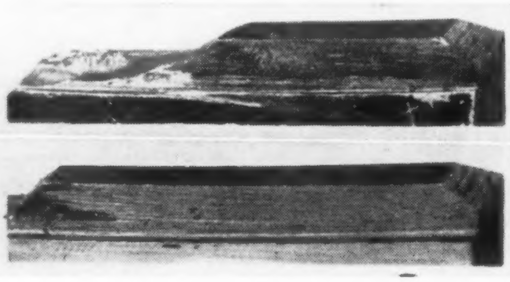


FIG. 23 GEAR FAILURE
(Fig. 23 *a* at top; Fig. 23 *b* at bottom.)

find what was wrong with the material to cause the fatigue failure. Note that the failed tooth is broken at one end which, incidentally, is typical of almost all failed gear teeth. An adjoining unbroken tooth, shown in Fig. 23(*b*), tells us that failure occurred because only a small part of the tooth was actually supporting the load in spite of the generous tooth length that was provided by the designer. This gear would have been just as durable had it been designed to one fifth the tooth width that was actually provided. Clearly, this is a mechanical and not a metallurgical problem. The real trouble was inadequate support of the gears and other mechanical errors, as previously noted.

It may fairly be argued that this is an unusually severe case and that it is not typical of gear fatigue. Actually, the most unusual thing about it was that it could be diagnosed before it was cut into sections and the evidence etched away as so often happens in metallurgical examinations.

In the case of fatigue failure of mating helical gear teeth of equal strength, fatigue will always occur in the tooth that is loaded on its acute-angled end because the section is weaker at this end. Mating helical gears should be offset so that contact cannot occur on the acute-angled end by any mode of deflection. This is possible only where the torque is constant in direction (8).

All gear teeth should be designed to afford a degree of tolerance for deflections, machining errors, and warpage as has long been standard practice in spiral-bevel (9), hypoid, and in some spur and helical gears. In "rigidly" mounted gears, this is accomplished by curving the tooth "barrel-shape" or equivalent, in such a manner as to concentrate the load near the center line of the gear width and thus avoid load concentration at the weaker extreme ends of the teeth.

Load concentrations at the ends of gear teeth can sometimes be avoided by increasing the elastic deflection, as is done in simple spur reduction gears, by providing the gear with a thin diaphragm web ocated in the center of the gear width, or by more complex construction in other forms of gears, but it cannot be done by accurate dimensions alone.

GEAR-TOOTH PITTING

The pitting of gear teeth is a form of fatigue that is induced by tensile stress from compression loads on the contacting tooth surfaces. The magnitude of the compression stress varies with relative curvature of the contacting teeth in accordance with the Hertz formula; it varies with the degree of load concentration at the ends of the teeth and with the applied load. The load that may be carried varies with the hardness, and therefore with the strength of the material, with the temperature, and with the manner in which the lubricant is applied.

The design factors that are effective in reducing the load concentration at the ends of the teeth, barrel shaping or equivalent, also reduce the contact compressive stress. The relative curvature and therefore the contact compressive stress can be varied by the choice of pressure angle. In general, there is little to be gained by designing wide-face gears except the doubtful satisfaction of dealing with smaller stress numbers.

In high-speed gears, pitting may occur when gears are transmitting no load. This is sometimes seen in the reverse idler gear of the automobile transmission. Although this form of transmission trouble is rare and occurs only when other conditions, such as hardness, are unfavorable, it serves to emphasize the part played by the lubricant in promoting fatigue. A reverse idler running submerged in oil will trap the oil between the gear teeth and if the clearances are small will induce extremely high surface pressures. We are all familiar with the high temperatures that are generated in gearboxes when too generously supplied with oil, but we do not always interpret this as a fatigue hazard. High-speed gears should be lubricated by jets of low-viscosity oil directed at the teeth as they are coming out of mesh, not on the incoming side. This form of lubrication will wash away the heat of friction while it is still on the surfaces of the teeth and will prevent excess oil from reaching the contact teeth providing of course that the sump is dry.

COMPROMISE TREATMENTS

Many materials and processes have been graded and are still being graded by laboratory tests. This procedure is now known to have been very costly to industry. For example, the fiction that a carburized part should have a hard case to resist wear, and tough core to resist breakage, arose from laboratory impact tests. In these tests the strength of the part was judged by the number or intensity of hammer blows it would withstand before fracture. Since gear teeth resisted impact fracture in accordance with the physical properties of the core, it seemed logical to specify heat-treatments to bring out the best compromise between the imagined requirements of the case and the core. Being compromises, these heat-treatments were not the best for either region.

If, instead of counting the number of impacts or measuring the intensity of hammer blows to produce fracture, the gear tooth had been examined after the first impact, the tooth would have been found bent and, therefore, ruined, and it would make no difference how many more blows were required to fracture the tooth.

This compromise heat-treatment resulted in reducing the quality of many millions of gears before it was realized that gear teeth fail by fatigue and that fatigue failure, for the usual depth of carburization, always originates at the surface of the case. From this evidence it became clear the heat-treatment should consider the requirements of the carburized case only, and that the properties of the core were relatively unimportant, because in bending and in torsion, the core serves mainly as a stuffing for the case.

PHYSICAL TESTS

Several kinds of impact tests are still being used and impact specifications appear in many drawings but no one can explain

and substantiate the significance of the test in terms of the service strength of machine parts.

Elongation and reduction of area are carefully measured and are prominent in our specifications, but we do not know their meaning in terms of serviceability of machine parts. We are told that "brittleness" must be avoided but no matter how brittleness is defined it does not explain why this property is necessarily more harmful than ductility. Most machine parts that are plastically deformed are just as surely failed as if they were broken. We are asked to believe that machine parts generally must possess relatively high ductility, and they must therefore be heat-treated to develop this property. However, when we really get down to applying severe dynamic loads, we forget about ductility and specify high hardness that certainly is well within the range of brittleness in the usual meaning of the word. Strong fatigue-resistant gear teeth are file-hard. Wrist pins, ball bearings, roller bearings, shafts, and cams are hard, and they are strong and fatigue-resistant because they are hard.

A gear tooth is just as surely a spring as the coil that actuates a valve. Why, then, must the one be hard and "brittle" and the other be relatively soft and "ductile?" Why can we not avail ourselves of stronger hardened materials? The answer may lie in our concept of brittleness. We do not fear brittleness from the hardness when hardness is obtained by nitriding. Nitrided surfaces are not notch-sensitive because they are stressed in compression.

Notch sensitivity is probably the inability of a nonductile material to yield locally and thus reduce tension stresses in local highly stressed regions, such as notches and scratches. The amount of ductility that is required to overcome brittleness depends upon the amount of yield that is necessary to reduce local tension stresses. If the surface is sufficiently pretressed in compression, local yielding is not required, and therefore nonductile materials will not be "brittle." As we improve our understanding of brittleness we may expect to use steels at higher hardness in many parts for which we now specify ductility. We will then gain from the greater inherent strength as well as from the increased strength obtained from compressively stressed surfaces.

The most significant of our easily performed laboratory tests is hardness. Since the static strength of most materials is roughly proportional to hardness, we will know the approximate static strength of a part if the hardness is accurately measured. However, the popular hardness testers such as Brinell or Rockwell are incapable of the accuracy that is required because they penetrate too deeply into the material being tested, and therefore they do not measure the characteristics of that most important part of the material, the surface layer.

Chemical analysis can only indicate the responsiveness to heat-treatment and can measure the potential strength of a steel only by its probable hardenability. Since strength is proportional to hardness, all properly heat-treated steels of equal hardness are equally strong regardless of their compositions.

Laboratory hardenability tests are now coming into general use. This test has much merit providing that we understand its meaning and that we do not debase it, as we are so prone to do by applying arbitrary hardenability specifications without considering the requirements of each particular part. Through-hardenability (approximately uniform hardness through the section) can be very important for parts that are stressed in tension, but it is difficult to see why through-hardness is necessary in parts that are loaded in bending or in torsion because in such members the stress decreases somewhat linearly, with depth reaching zero at the neutral axis. For this kind of loading, it would seem to be more important to develop heat-treatments that give the type of internal stress shown in Fig. 15, because, being prestressed negatively to the applied tension load, the dynamic-load-carrying capacity is greatly increased.

The standard laboratory tensile test is, of course, incapable of indicating the useful bending or torsion strength of prestressed specimens, particularly when the prestressing is deep, as shown in Fig. 15. For such specimens, the tensile test cannot even distinguish between harmful and beneficial prestressing. Both would probably show decreased tensile strength, whereas under dynamic bending or torsion loads one would show greatly decreased fatigue strength and the other greatly increased fatigue strength.

However, we have done a reasonably satisfactory job in the past without worrying overmuch about the shortcomings of the methods used. We may be certain that we will do better in the future as more experience is gained, and it is in the accumulation and organization of this experience that we can best serve the needs of the future. It is probable that fatigue studies will play increasingly important parts in future designs; but these studies will be based on fatigue tests of actual, full-scale machine parts instead of on laboratory specimens.

FATIGUE TESTS ON MACHINE PARTS

Fatigue tests of full-scale machine parts have been made by many laboratories for a long time but, since these tests have usually been made for the purpose of comparing one material, design, or process with another material, design, or process, the tests have been run at arbitrary constant loads without thought to the fatigue curve characteristics, and often without adequate correlation with service requirements. Because of this procedure, we have made little use of the vast quantities of such fatigue data as are now locked in our files, in so far as establishing a basis for evaluating material, design, or process for the future is concerned.

In the few cases where fatigue data on machine parts have been properly organized, we find that they reveal astonishing amounts of fundamental information about the many variables that are present in machine elements, many of which are not even qualitatively revealed by ideal laboratory fatigue specimens.

FATIGUE DATA ARE MORTALITY DATA

Fatigue data are mortality data, and it is just as absurd to expect that reliable actuarial tables can be constructed from mortality data on a half-dozen individuals as to expect that reliable comparisons can be made from fatigue tests on a half-dozen machine parts. Heindlhofer and Sjövall (10) have shown life-expectancy curves for commercially identical ball bearings, for commercially identical mazda lamps, and for human beings. These curves are shown in Fig. 24, in which the ordinate is the percentage of units surviving and the abscissa is durability in per cent of average life.

Fig. 25 is a life-expectancy chart at constant load for commercially identical transmission gears in complete automobile transmissions, for commercially identical rear-axle gears in complete automobile rear axles, for commercial automobile fan belts (11), for commercially identical bolts, and for a group of ideal laboratory fatigue specimens. Similar life-expectancy curves will result whether applied to mountain ranges or to the hairs on our heads.

Although the general form for all life-expectancy curves is the same, they differ in detail. Note that the expectancy curves for machine parts, Figs. 24 and 25, do not extend to zero life as is the case in the human expectancy curve. Infant mortality is avoided in machine parts because the parts having a low potential life are rejected by factory inspection, a practice that is not followed for humans.

VARIATION IN DURABILITY

Another important difference is the relative life span for various machine parts. Note that for automobile rear-axle gears the life span of the most durable unit was about 4 times the life span of the poorest unit, but for automobile transmis-

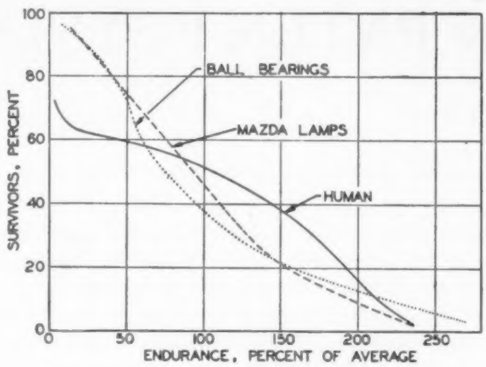


FIG. 24 COMPARATIVE ENDURANCE

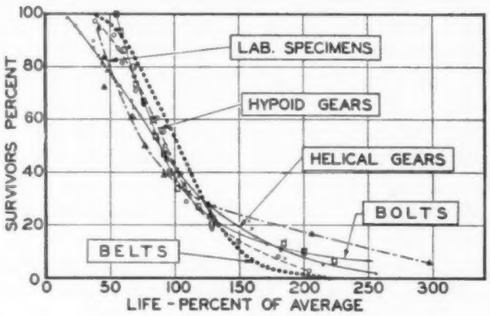


FIG. 25 SIMILARITY OF LIFE EXPECTANCY

sion gears the life ratio from the best to the poorest was about 15 to 1, that is, childhood mortality is higher in automobile transmissions than in automobile rear axles. The life-span ratios just given should not be taken literally because there are not enough test points in either curve to define their limits. As the number of test points is increased, the life ratio of the best to the poorest will increase but the "scatter" will be greater for transmission gears because the variability of stress resulting from end contact is greater.

The percentage variation in life of machine parts will also change as the test load or load range is changed. When tests are conducted at high load or high load range to produce fatigue failure after relatively few stress cycles, the percentage variation from the best to the poorest will be less than if the test is conducted at a lower load to produce fatigue failure after a relatively large number of stress cycles. The reason for this variable will become clear when we examine the form of scatter band of fatigue data from a sufficiently large number of fatigue tests.

In the class of light machines, where weight must be conserved, it will probably never be possible to design mechanisms to withstand all the abuses that are encountered in service. If an airplane engine, for example, should be so sturdily designed that the shortest-lived of each of its numerous parts would be failure-proof under all the abusive conditions that may be experienced in service, the engine would be so heavy as to be impractical. As we learn how to increase the durability of each machine element, we will reduce but not eliminate failure hazards. Instead, progress will demand that we take advantage of such improvements by reducing the weight or by increasing the power output.

INSUFFICIENT TEST DATA

Reliable life comparison of machine parts demands a large number of tests unless the life difference is very great. It is obvious from the mortality charts that, on the basis of a few tests, the poorer design, material, or process may rate higher than the better design, material or process. Yet nowhere in the literature do we find fatigue data approaching even the minimum requirements of reliability. The reason is largely that most of the investigators in this field, particularly in work on steel, assume that we have no interest in data at any stress except the stress at which the specimen will endure indefinitely.

In practical fatigue-testing of machine parts, it should be obvious that comparisons of material, design, or processes cannot be made unless the tests are run to failure and the comparisons are made on the number of stress cycles each will endure. This is true whether or not the part being tested is required to withstand, in service, a very large number of stress reversals at maximum load, such as a crankshaft, or a relatively small number of stress reversals at maximum load, such as chassis springs. Since all representative tests are made at loads that result in failure by fatigue, our interest lies not in the fatigue endurance limit where for steel, under most test conditions, life is infinite, but in that portion of the fatigue curve to the left of the "knee" where life is finite, that is, the sloping part of the curve.

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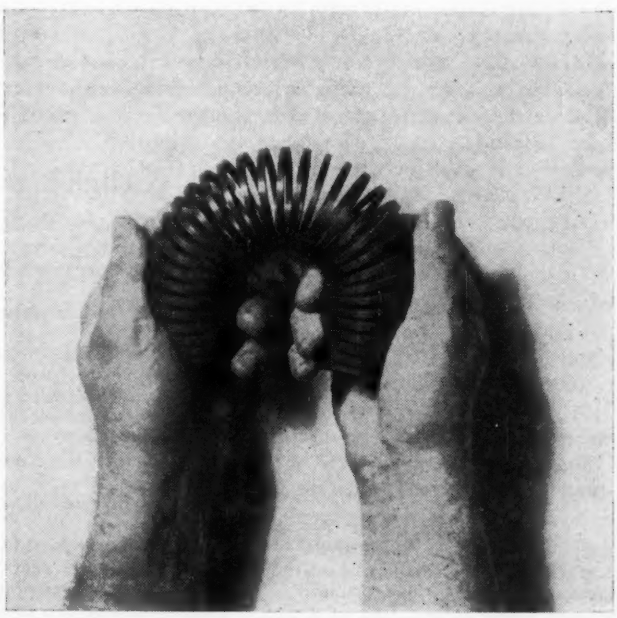

SHOWING HOW FLEXIBLE CAST IRON CAN REALLY BE

(This spring was cut from a cylindrical casting made of Meehanite metal, an improved form of cast iron being used in castings by the Cooper-Bessemer Corporation.)

REPORT *on the* AMERICAN PATENT SYSTEM

By A. A. POTTER

DEAN OF ENGINEERING, PURDUE UNIVERSITY, AND EXECUTIVE DIRECTOR, NATIONAL PATENT PLANNING COMMISSION

On Dec. 12, 1941, the President of the United States of America, by Executive Order No. 8977, created the National Patent Planning Commission "to conduct a comprehensive survey and study of the American Patent System." The first report[1] of the Commission, transmitted to the President on June 9, 1943, is concerned with questions of broad policy arising in connection with the patent system itself and the use of patents. The following summary of the conclusions and recommendations in this first report of the Commission is of interest to the engineer, as he realizes that a sound patent system is needed to provide adequate protection, as an incentive for the inventor to create new machines and processes, and as an inducement to the investor to finance the conversion of the invention into a marketable product.

1 *The Patent System of the United States.* The Patent System is the foundation of American enterprise and has demonstrated its value over a period coextensive with the life of our government. The principle of recognizing a property right in intellectual creation is sound and should be continued as contemplated in the Constitution.

2 *Patents and the War Effort.* This involves no serious problem since under existing laws the government has the right to use any patented invention. Although full opportunity has been given, and specific inquiry made by the Commission of the armed services, no evidence has been submitted of specific instances of the use of patents to hamper the war effort.

3 *Protection of the Public Interest.* The Commission believes the public interest can be further protected by several modifications in and additions to the patent laws. These changes will serve to prevent the abuse of the rights granted by patents while maintaining the fundamental principles of a tried and proved system.

To expose secret, improper, or illegal agreements, it is proposed that all patent agreements be recorded with the United States Patent Office.

It is proposed that in a suit for infringement a patent owner shall be limited to reasonable compensation without prohibiting the use of the patented invention whenever the court finds that manufacture of the invention is necessary to the national defense or required by the public health or public safety.

To invalidate patents which later information shows should not have been issued, a provision is proposed for cancellation of an issued patent.

4 *Extending the Use of Patents.* It is recognized by the Commission that our system should afford a patent owner an opportunity of publicly declaring his willingness to grant licenses under reasonable terms. A public register of such patents in the Patent Office is therefore proposed.

5 *Uniform Standard of Invention.* One of the greatest technical weaknesses of the patent system is the lack of a definitive yardstick as to what is invention. To provide such a yardstick and to assure that the various courts of law and the Patent Office shall use the same standards, several changes are suggested. It is proposed that Congress shall declare a national standard whereby patentability of an invention shall be determined by the objective test as to its advancement of the arts and sciences. It is further proposed that when the validity of a patent is challenged in an infringement suit the court record shall be referred to the Patent Office for its opinion in the light of any new evidence or facts developed during the trial. Finally, it is proposed that a single court of patent appeals be established.

6 *Early Termination of Patent Grant.* A patent application can be delayed and kept pending for undue and prolonged periods. This postponement of the beginning and ending of the patent term is not in the public interest. It is proposed that the patent term shall not endure more than twenty years after the application is filed. The present term of seventeen years would be retained except in those cases where more than three years were consumed in obtaining a patent. Delays of more than three years in the prosecution of an application for patent would result in a corresponding shortening of the seventeen-year term.

7 *Simplification of Appellate Procedure.* When a patent is refused by the Patent Office the inventor now has relief in the form of review by either of two courts. This is both confusing and unnecessary. It is proposed that the Court of Customs and Patent Appeals be designated as the sole reviewing body upon the denial of a patent by the Patent Office.

The Commission is now engaged in a study of the policies involved in connection with inventions made by Government employees and by agents and contractors of the Government, and with the control and use of patents owned by the Federal Government. It is also conducting a study in fulfillment of the final directive of the Executive Order, i.e., "what methods and plans might be developed to promote inventions and discoveries which will increase commerce, provide employment, and fully utilize expanded defense industrial facilities during normal times." The results will be the subject of future reports.

It is hoped that the recommendations in the first and in the subsequent reports of the National Patent Planning Commission will tend to strengthen the American patent system and lead to a better understanding of its functions and operations on the part of the public, while encouraging interest in inventions and in their utilization for the benefit of humanity.

High Lights of the Report

The principle of recognizing a property right in intellectual creation is sound and should be continued.

No serious problem is involved in patents in the war effort.

Proposed modifications of existing patent laws are provisions for:

Recording of all patent agreements.

Limiting suit for infringement to reasonable compensation without prohibiting use of the patented invention if the invention is necessary to national defense or public health or safety.

Cancellation of patents which should not have been issued.

A public register of patents for which the owner will grant licenses.

A national standard for determining patentability.

Referring court records in infringement suits to the Patent Office for an opinion.

Establishment of a single court of patent appeals.

Limiting patent term to not more than 20 years after application is filed.

Designating Court of Customs and Appeals as sole receiving body upon denial of a patent by the Patent Office.

[1] "The American Patent System," Report of the National Patent Planning Commission, Washington, D. C., 1943. The personnel of the Commission: Charles F. Kettering, *chairman;* Chester C. Davis, Francis P. Gaines, Edward F. McGrady, and Owen D. Young; Andrey A. Potter, *executive director;* Conway P. Coe, *executive secretary.*

FARM WORK SIMPLIFICATION

By M. E. MUNDEL

PURDUE UNIVERSITY, LAFAYETTE, IND.

FARMERS today have the task of meeting increased agricultural demands despite shortages of production means. One of the most crucial shortages is the limited supply of manpower. If the production goals are to be approached it is essential that every farm laborer work at maximum efficiency. Additional farm machinery is not readily available. Present supplies of farm machines cannot be much enlarged this year. Increased mechanization of agriculture is not an available means of increasing the output per farm worker. The labor required to maintain or increase present crop acreages and livestock numbers must come from more work from each farm worker; more accomplishment rather than more effort. Means of making more efficient the use of human labor on farms must be worked out. One of the most promising means of achieving this is to determine principles by which farm jobs may be improved so as to permit more work to be done with the available effort. Most of the research in means of improving labor efficiency on farms has been from the standpoint of farm organization and combination of enterprises. The farm layout, building organization, and combination of enterprises have been studied in regard to the profitableness of farms. From these investigations, principles of business organization and management resulting in profitable operations have been established.

While the foregoing approach is useful, there is further need for improving economically important individual farm jobs. Large economies in manpower and increases in labor efficiency have been secured in industry by the application of principles of work simplification or motion study. The application of motion study to farm jobs has lagged.

Motion and time study is taken to mean a scientific systematic analysis of ways of doing work to eliminate all unnecessary work, provide the best sequence for the retained work, provide the best conditions for the performance of each motion of the job, standardize both the way of doing and the amount of time required to do the job and also see that this is developed into practice.

While agriculture differs somewhat from industry in organization and in the number and variety of tasks performed by each worker, it is felt that work-simplification studies applied to agriculture can make substantial contributions to agricultural production.

Two particular areas in farm work have to be covered as follows:

(1) The general problem of chores and other occasional jobs;

(2) Repetitive operations such as those connected with planting, harvesting, and packing.

Contributed by the Management Division and presented at the Spring Meeting, Davenport, Iowa, April 26–28, 1943, of The American Society of Mechanical Engineers.

TABLE 1 FARMER-LABOR CHECK LIST

1 Can this operation be eliminated? (What would happen if I didn't do it?)
2 Can a substitute way be used that will decrease labor and costs?
3 Can the existing machines be more fully utilized?
4 Are the machines kept in top form?
5 Can the order of work be changed so as to allow more work with less physical effort?
6 Can some little stunt ease a job? Reduce the time needed to do it?
7 Are you overexerting yourself by stooping? Lifting the hard way?
8 Can excess travel be eliminated by: (*a*) Planning work, (*b*) changing the places where things are kept, (*c*) combining jobs?
9 When you do some repetitive job can you: (*a*) sit comfortably, (*b*) let gravity help, (*c*) have both hands work instead of one holding, (*d*) make the job safer, (*e*) use a better tool, (*f*) arrange your work so that everything is within elbow reach, (*g*) use available labor?
10 What is the best time to do a job?
11 Have you a list of rainy-day jobs?
12 Do you train help in the best way to do a job?
13 Do you train help in the best way to use tools?

GENERAL EDUCATION BOARD SETS UP LABORATORIES

To aid in the application of motion and time study to the farm problem, the General Education Board made a substantial grant to be used in setting up farm-work-simplification laboratories in the land-grant colleges of the United States. The fund is administered by E. C. Young, dean of the graduate school of Purdue University. The first research laboratory was established at Purdue University in the winter of 1942–1943 as a joint project of the agricultural and engineering experiment stations, with the aid and co-operation of the administrators of the experiment stations, Dan Braum of the U. S. Department of Agriculture and Dr. Lillian M. Gilbreth.

The Purdue Farm Work Simplification Laboratory also trains agriculturists from other schools in motion- and time-study techniques and to date has trained men from Colorado, Minnesota, Nebraska, Illinois, New York, Florida, Kentucky, Connecticut, and New Jersey. These men will help lead the laboratories in their own states and carry on investigations into their regional problems.

The laboratory at Purdue has also a specific program of research to ease the farm-labor situation, as well as a pilot and training function. It has been mentioned that there are two areas in farm work to be covered: (1)The general problem of chores and other occasional jobs; (2) repetitive operations including those connected with planting, harvesting, and packing.

In the second area, the laboratory at Purdue has two studies under way, one concerning itself with the bottleneck operations on the Indiana tomato harvest such as picking and peeling and the second with a complete study of hog operations. Of these the laboratory hopes to be able to report progress later this year.

MAKING THE FARMER MOTION-MINDED

In the first area, that of chores and occasional jobs, it would not be economical to work out the individual solutions to each farmer's problem and hence this part of the work is an educational task. It is necessary to make the farmer motion-minded, and to provide him with the principles of work simplification so that he can do something about it.

The laboratory at Purdue has prepared educational material on an experimental basis and enlisted the aid of the agricultural extension services to carry this information to the farmers. A large phase of the problem of present-day motion and time study is the education of people to use the techniques rather than developing the techniques themselves. Since the farmers represent a tremendous group similar in many ways to a direct labor force and since the material is also unfamiliar to them it is probably worth while to examine the program for farmers not only with the farm program in view, but also in respect to the light it may shed on educational problems involving motion and time study in industry. The first question to be answered

by any educational program is the "why" of its existence. This should be followed by the material itself, presented in such a way that the learner participates in the learning process.

For the farm groups, the extension agents with the present experimental procedures present the following material:

1 An introduction to work simplification in the form of a short talk.

2 A film giving a check list for the application of work-simplification principles to farm work and illustrations of the applications. The emphasis has been concentrated on the principle rather than the illustration. That is, we feel, one of the chief assets in motion study and second only to the basic questioning attitude. This film is designed to stimulate questioning and to teach principles rather than practices.

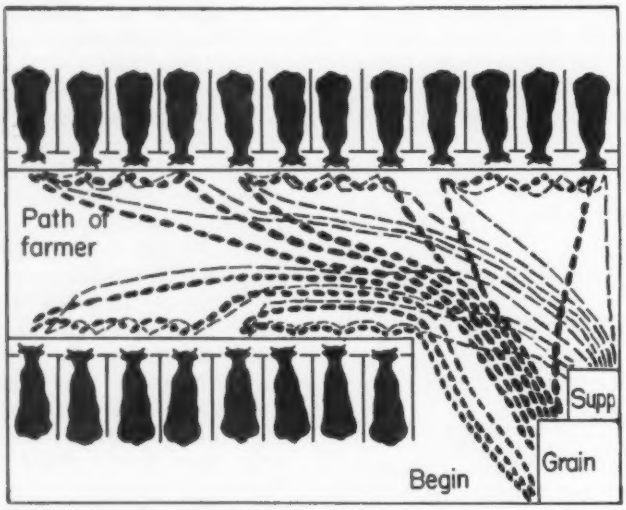

FIG. 1 AN ORIGINAL METHOD USED BY A FARMER FEEDING HIS COWS

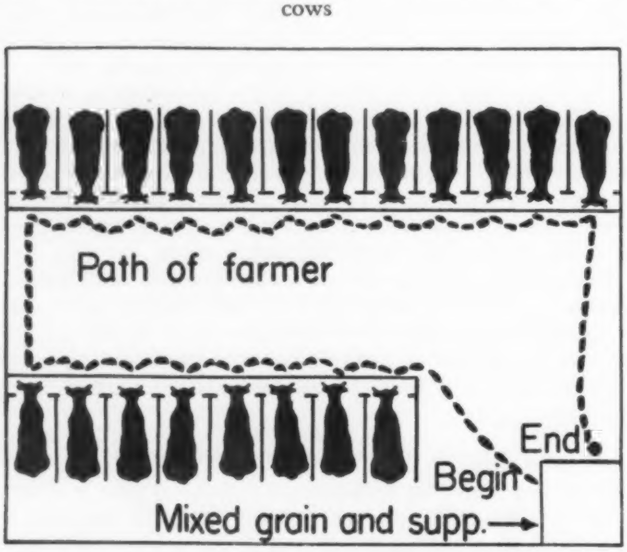

FIG. 2 AN IMPROVED METHOD OF FEEDING COWS (SEE FIG. 1) WHICH SAVES 45 MILES OF WALKING EVEY YEAR

3 A participational aid to take the information out of the realm of something that is merely seen into the realm of something that is thought about in connection with the farmer's own work. This is in written form so as to aid the memory and is handed out to each farmer at the meetings and then discussed.

Table 1 is the experimental work-simplification check list developed to aid the farmer in finding better ways of doing his chores and occasional jobs. Each of these questions is illustrated in a film by an example showing how the principle may be usefully applied.

Fig. 1 is the original method used by one farmer in feeding his cows. This illustration is used to show the application of Question 8: "Can excess travel be eliminated by (*a*) planning work, (*b*) changing the places where things are kept, and (*c*) combining jobs."

This path which the farmer walks is developed as an animated movie which traces the farmer's path so as to enable the audience so see the development of this laborious energy-wasting procedure.

The improved method is shown in Fig. 2 which is also developed as an animated movie. By mixing the two feeds and using a feed cart this farmer can save 45 miles of walking a year.

The participational follow-up for this question, issued after the showing of the film, is shown in Fig. 3. Blanks are provided on this follow-up to aid discussing further improvements or applications of the same principle to jobs done by those in the audience.

The experimental educational program is roughly as follows:

Principle 8. CAN EXCESS TRAVEL BE ELIMINATED BY: (A) PLANNING WORK? (B) CHANGING THE PLACES WHERE THINGS ARE KEPT? (C) COMBINING JOBS?

Example	Original Method of Doing Work	An Improved Method of Doing Work	What Improvements Do You Suggest?
(A) Feeding Dairy Cows	Farmer makes trip to each four cows with grain, and another trip with supplement.	Grain and Supplement combined. One trip with feed cart does the job. Eliminates 45 miles of walking per year.	
(B) Watering Stock		Tank set in fence between two lots; One filling does two jobs.	
(C) Trucking Feed to Elevator	Half a load of corn.	Full load of corn: Half as many trips required, Saves tires, gas and time.	
Your Jobs			

FIG. 3 PARTICIPATION FOLLOW-UP FOR WORK SIMPLIFICATION PRINCIPLE NO. 8

1 We try to tell the farmers what they are going to see and what we are trying to show them.

2 We attempt to establish the "why" of the program.

3 We present the information to them using color, animation, and careful editing to emphasize the work-simplification principle rather than the specific farm practice.

4 We try to create participation by supplying material which ties into what they have seen, "remembers" it for them, and aids in an extension of it into what they are themselves doing.

An examination of this program suggests that the same general area in industry would also benefit from a carefully designed attack. The occasional job in industry, the nonrepetitive work, permits the same general solution. It requires the development of a check list of principles, examples, and some participational device.

A unified visual, oral, written, and, above all, participational presentation of a carefully planned set of principles keyed directly to the work in hand suggests itself as the way to quickly develop motion-mindedness on a wide scale.

SCARCE MATERIALS *Are* VITAL *to the* WAR EFFORT

By W. J. CLARDY

TRANSPORTATION APPLICATION ENGINEER, WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, EAST PITTSBURGH, PA.

IT IS essential that scarce materials needed for the war effort be utilized expeditiously to assure maximum benefits. A united front is required in manufacturing and maintenance to make the dwindling stocks of many strategic materials most effective. The importance of this action cannot be overestimated. Substitution, reduced use, scrap recovery, and changes in maintenance and shop practices are factors to be considered in this "home-front" battle.

SCARCE MATERIALS

Scarcity is caused by the accelerated demands of war industries or the diminished foreign supply. The situation is subject to day-by-day change as armament requirements increase and progress is made in the use of substitutes. Under the present allotment program, the effort is to make an equitable distribution of the available materials for uses essential to the war effort. The supply of many items is far below requirements and such materials must be directed into the most useful channels that serve military purposes. Manpower and production capacity no longer appear to be the crucial factors in the manufacture of goods; the problem is to obtain the needed materials.

The distribution of scarce materials is very closely controlled by the War Production Board. Quality is definitely regulated in the interest of securing the most effective use of components which have limited availability. The latter phase involves many "wartime" changes in specifications. Securing materials for which the demand exceeds the supply involves establishing a need which is essential to the war effort. Where a diversity of materials and equipment are used this has naturally become a major undertaking.

While the relative scarcity of materials is subject to daily variations, dependable data are obtainable on the current situation. The Conservation and Substitution Branch of the Conservation Division, W.P.B., is continually studying the problem and publishes information on various critical materials. A list made available February 1, 1943, includes all items classed as "insufficient for war demands and essential civilian demands." The data may be summarized as follows:

Material	Total	Most critical — Number	Most critical — Per cent
Metals	18	11	61
Steel products	11	4	36
Chemicals	63	9	14
Alloy steels	7	2	29
Plastics	13	1	8
Lumber	24	1	4
Textiles and fibers	21	6	29
Other products	54	18	33
Total	211	52	

The scarcity of tin has caused considerable concern. Its primary use is as an auxiliary to other metals for making solder, babbitt, bronze, and covering iron containers. Tin is of ancient origin, but its general use in modern civilization dates from the beginning of the present century. A major portion of the tin supply came from the Far East, a source which is now closed to the United Nations. About 58 per cent of world production has thus been lost to the Allies. There will be increases in the Latin American and African output, but the available supply will fall far short of meeting requirements.

The shortage of rubber has received much publicity because it affects the activities of every citizen. It has been used in the United States at the rate of 766,000 long tons per year. It was employed in the manufacture of more than 50,000 products, many of which contribute to what is termed "the American standard of living." In 1941, rubber importations exceeded 1,000,000 long tons from sources as follows:

Country	Long tons
Malaya	550935
Netherlands East Indies	367373
Ceylon	59804
Burma, Thai, and Melanesian Islands	20511
Latin America	10753
Africa	10419
Other countries	5768
Total	1025563

The Far East supply, representing more than 95 per cent of the total, is no longer available. A substantial portion of the 1941 importations was placed in a stock pile to assist in meeting the demands of the next two years. This will require allocating every pound of rubber for essential military purposes and the minimum needs of civilian economy. Also, there must be a miracle in synthetic-rubber production capacity to produce at a rate of 800,000 tons annually by the end of 1943. The military needs for rubber are tremendous, as is indicated by the following:

Material	Pounds of rubber
37-mm AA gun carriage	190
Scout car	340
Flying Fortress	1450
28-ton tank	1750
10-ton pontoon bridge (5 floats)	3200
Battleship	150000

MEASURES TO RELIEVE SHORTAGES

Intelligent planning of conservation measures requires a thorough knowledge of the current material situation. In addition to having the facts on items which are unavailable, it is essential to have definite information on what might be used in their place. The Conservation and Substitution Branch of the Conservation Division, W.P.B., included in the report dated February 1, 1943, a list of materials sufficient for immediate war and essential civilian uses. There are 29 metals, alloys, and steel products, 36 chemicals, and 93 other products. Supplies are reported to be reasonable with respect to the war demands although the availability of some is attributed to restrictions placed on consumption for nonessential uses. A list of materials available in significant quantities for substitution purposes is also given that includes 7 metals, 16 chemicals, and 120 other products. This group covers few metals and chemicals; it comprises the mass products of coal mines, forests, fields, oil wells, and quarries. The exercise of ingenuity and resource-

fulness in getting these items into replacement use for essential military and civilian needs may be an important factor in winning the war.

Some products will require essential materials and a great deal can be accomplished by decreasing quantities expended to the safe and efficient minimum. Under existing conditions, efficiency must be viewed as the most expeditious use of available material stocks rather than an economic consideration. This may result in increased costs in some instances although the intensive investigation required is certain to produce many improvements.

The practice of discarding material which has remaining useful life has built up potential supplies that have long been overlooked. Reclamation assists in reducing the demand on available stocks by converting what are termed "waste products" into usable items. Careful search of manufacturing and shop premises is in order to secure the maximum benefits from a program to recover all existing material. The possible returns warrant a permanent assignment of the project in any sizable plant or shop. The benefits are certain to be a measurable contribution to the war effort even in establishments which have a reputation for efficient utilization of supplies.

Another factor to be considered in conserving scarce articles is securing longer life from all parts. Obviously, this will reduce the need for new stock and lower the consumption of material. It is possible that labor costs will be stepped up slightly incident to more frequent inspections, but an over-all increase in operating expense is unlikely. In the attempt to solve the shortage problem there must be replacements and decreased use of critical materials, utilization of discarded items, and longer life secured from all products.

SUBSTITUTIONS AND REDUCED USE

The results of substitutions show that much can be achieved when the urge of necessity requires constructive action. Tables 1 and 2 include lists of substitutions which have been made in electrical manufacturing, the former applicable to metals, and the latter to other products. There are 25 items among the metals with aluminum, nickel, stainless steel, tin, and tungsten prominent in the program. Eleven other products are listed for which substitutes are used. Replacement of materials in electrical machinery creates a major problem due to the application diversity of various designs. For example, a substitute steel might have greater tensile strength, ductility, and toughness than one replaced, and still lack an essential friction characteristic. Tables 1 and 2 also show 6 metals and 8 other products which are being saved by a reduction in their use.

Specific examples of savings made in critical materials are numerous. The world's supply of paint-brush bristles has long come from the Orient, the final source of supply being China, which was lost with the closing of the Burma Road. A 45 per cent horsehair substitute is conserving existing stocks but performance fails to measure up to pure bristle brushes. Spray-painting can be utilized more extensively while developments under way give promise of producing satisfactory synthetic bristles. Chinawood oil is an important ingredient of high-grade finishing paints. Its pigment-suspension properties, drying characteristics, water resistance, and durability are advantageous. When imports from China ceased, some substitution became necessary. A specially processed dehydrated castor oil has been found suitable for the purpose and is obtainable in adequate quantities. Leather has become scarce and this has adversely affected the supply of belts free from lacing. It is now possible to employ fabric belts spliced with a new waterproof cement.

Airway beacons have long been made with aluminum castings. The total weight of aluminum per lamp was 250 lb. A construction has been devised which eliminates aluminum and provides a more satisfactory beacon. Incandescent lamps had brass screw bases which are now made from brass-plated iron. The filament wires were soldered to the base. They are now spot-welded to save lead and tin. In the case of fluorescent lights, the tubes were made of lead-oxide glass. This has been changed to lime glass. The bases which were plastic disks with nickel-plated collars have become one-piece plastic. Contact pins were copper, but are now changed to copper-plated steel. Dipping to secure a coating of tin, which often had irregularities and was thicker than required, is being replaced by plating. The exact thickness needed is obtained and an electrical heating process "brightens" the surface and removes small holes; the saving is 60 per cent. Pure tin solder has been replaced by one using only 15 per cent. Special high-temperature solder is made without tin. In the case of babbitt metal, it appears practical to eliminate almost entirely the use of tin; and bronze journal-bearing shells have been reduced to one half their former thickness.

The American railroads are among the greatest users of steel. Standardization on smaller sizes has produced favorable results. For example, the angle bars joining the ends of rails ranged from 24 to 39 in. A 24-in. standard has been established which saves some 12,000 tons of steel per year. Normally the railroads require close to 50,000 tons of copper per year. Action is under way to reduce the amounts used in locomotives, air brakes, signal apparatus, telephone and telegraph communications, and journal boxes. The over-all saving is 10 per cent. The railroads have substantially curtailed the consumption of rubber and the Association of American Railroads has been active in recommending substitutes. Latex was used to give an adhesive quality to soft lubricating greases employed in loosely fitting bearings on locomotives. Work is under way to secure this desirable property without the rubber latex. Fiber felt, plastics, reclaimed rubber, and various other materials are used to make 78 different parts and appliances now employing rubber as is shown in Table 3. This has been done without adversely affecting efficiency or safety. Rubber has been reduced in the manufacture of 27 other items included in Table 4. Rubber hose is an item needed in substantial quantities. Emergency specifications of the Association of American Railroads permit the use of reclaimed rubber although the expected life will likely be less than one half that formerly secured. Careful consideration is essential in the case of a substitute of this kind because of safety. For example, its application for air-brake hose would be unwise, as a failure might cause a serious accident. This is a modification in the use of rubber which is uneconomical and will ultimately lead to a greater demand because of the short life of the substitute.

SCRAP RECOVERY

The railroads are important sources of scrap and have had recovery programs for a good many years. Reclamation is a specialty and is considered as such by most of the properties. One system has had a superintendent as far back as 16 years ago, and specialty men are employed extensively. Centralized plants have proved to be the best means of reclamation. These provide the most efficient handling, shipping, sorting, selection of items that may prove usable, distribution, and stock control. The needed materials can be repaired and reclaimed while those which are of no use may be disposed of as scrap.

Regardless of long-established scrap-recovery programs, more intensive searches recently inaugurated have produced startling results. One large railroad system which was early to initiate an intensive salvage program has collected and sold 330,000 tons of iron and steel scrap since the beginning of 1939, the first year of the war. The attack on Pearl Harbor gave further impetus to the program, and the drive is continuing for the "duration." Results indicate that much additional material can be uncovered by careful search. Abandoned gas, oil, steam, and water lines are often left in the ground. Their removal may not always be economical, but the shortage of material justifies

TABLE 1 SUBSTITUTIONS AND REDUCED USE OF CRITICAL METALS

Material	Change	Remarks
Substitutions:		
Aluminum	Malleable iron or steel	Saving 50,000 lb, monthly
Aluminum-chromium nitriding steel	Stainless-steel stampings and castings	....
Aluminum-chromium nitriding sheet steel	Carbon sheet steel, chromium plated	....
Aluminum-nitriding steels	Stainless steel (cutlery grade)	Substitute now replaced
Aluminum-nitriding steels	Carbon steel-(carbon and cadmium-plated)	....
Cadmium plating	Zinc plating (electrolytic)	Used on 70 per cent of all hardware
Chromium plating	Silver plating	Wax coat on silver plating
Monel metal	Silicon bronze	....
Nickel-alloy laminations	Silicon iron	50 per cent alloy for current transfer
Nickel-alloy steel	Chromium-molybdenum steel	Shafts for rotating machines
Nickel-alloy steel	Heat-treated carbon steel	Suitable for many applications
Nickel-chromium cast iron	Nickel-molybdenum	Except for heat resistance
Nickel-chromium steel	Chromium-molybdenum	....
Nickel-chromium steel	Chromium-manganese-sulphur	....
Nickel alloys	Copper-molybdenum	....
Phosphor bronze	Carbon steel	....
Stainless-steel stampings and castings	Carbon steel (chromium and zinc-plated)	....
Stainless-steel stampings and castings	Carbon steel (chromium and cadmium-plated)	....
Stainless-steel (nickel-chromium) spring wire	Cadmium plated music wire	Limited to noncritical applications
Tin cans	Glass and fiber containers	For solvents, oils, and varnishes
Tin cans	Lead-coated cans	For solvents, oils, and varnishes
Tin-plate ventilating fins	Zinc-coated sheet steel	....
Tin- and tern-plated wire, strip, and sheet	Copper plate	....
Tungsten high-speed steel	Carbon-chromium	For dies
Tungsten high-speed steel	Chromium-molybdenum	For dies
Reduced Use:		
Copper and copper alloys	Copper-clad steels	Control wire, switch blades, springs
Chromium-molybdenum steel	Chromium-magnesium-sulphur	....
Nickel-alloy magnetic steel	Nickel reduced	....
Tin babbitts	Lead-base babbitt	Tin almost eliminated in some cases
Tin solders	Lead content increased	Tin reduced over 50 per cent
Tungsten high-speed steel	Tungsten-molybdenum	For cutting
Tin bronze	Silicon-bronze	

TABLE 2 SUBSTITUTIONS AND REDUCED USE OF CRITICAL MATERIALS[a]

Material	Change	Remarks
Substitutions:		
Chlorine bleaching compound	New paper formula eliminates bleaching	Used to bleach sulphate pulp
Linen cord	High-grade cotton	....
Mica; India	Mica; Canadian and Mexican	....
Rubber dustproof gaskets	Felt dustproof gaskets	Generally applied
Sapphire jewel bearings	Glass bearings	New bearings give longer life
Shellac condenser-bushing insulation	Oil-filled bushings	....
Tapioca glue in coil structures	Corn dextrine glue	....
Toluol	Petroleum or hydrogenated petroleum products	....
Tung oil	Soybean, perilla, and synthetic oils	....
Tung-oil extruded tubing	Vinyl-dichloride tubing	....
Varnished silk	Varnished cambric and rayon	Generally applied
Reduced Use:		
Mica cross-connection insulation	Asbestos and glass	Replacements, 90 per cent
Mica edgewound commutator-field insulation	Varnished cloth	D-c and a-c below 6600 v
Mica plate	Manufacturing improvements	Saving, 10 per cent
Mica slot insulation	Fish paper and varnished cambric	All class "A," except special items
Mica slot and end insulation	Varnished cloth	D-c and a-c below 6600 v
Mica strand and conductor insulation	Asbestos and glass	Replacements, 90 per cent
Mica splittings, No. 6	More accurate tolerances	Saving, 10 per cent
Tung-oil copper-wire enamel	Synthetic oil enamel	Used for 50 per cent of applications

[a] Except metals.

such additions to the metal stock pile. Trash dumps have proved to be profitable sources of scrap. In one case, 36 carloads had been obtained from a dump in 1941. It was gone over again and yielded nearly 400 tons of material which gave a net return of almost $1500 after paying all salvage costs.

Buildings which are no longer used and left standing often contain considerable metal. Copper wire, hardware, iron and steel scrap, lighting fixtures, piping for gas and water lines, and plumbing fixtures are some of the items recovered when such buildings are retired and demolished. At one location an assortment of usable valves and pipe fittings of various sizes was discovered in an old steam tunnel. High-speed tool steel is scarce and cannot be purchased. Housecleaning of corners, bench drawers, ledges, lockers, pipe trenches, and pits has pro-

TABLE 3 RECOMMENDED SUBSTITUTES FOR RUBBER; ASSOCIATION OF AMERICAN RAILROADS

	Name of part	Substitute
1	Absorbers, shock	Springs
2	Aprons	Impregnated fabric
3	Arm rests	Hair or moss
4	Balls, hard rubber	Composition
5	Bands, band-saw wheels	Fabric or leather belting
6	Bands, boiler-tube and copper pipe tools	Coil springs
7	Belting:	
	(a) Flat, axle-light generator	Balata
	(b) Frictioned	Balata or leather

(*Table 3 continued on page 570*)

TABLE 3 (*Continued*)

	Name of part	Substitute
8	Belts:	
	(*a*) Boring machines	Leather
	(*b*) Fan, flat	Fabric
	(*c*) Frictioned, endless, flat	Fabric or leather
9	Block, engine assembly	Steel springs
10	Blocks:	
	(*a*) Cushioning	Scrap belting
	(*b*) Coupler carrier suspension	Spring mounting
11	Breakers, circuit, hard rubber parts for	Plastic fiber
12	Brush, car wash, rubber back	Wood, reclaimed rubber, reclaim old backs
13	Buffers, safety guard and spring hood	Scrap hose or canvas
14	Buffers and draft gear (Waughmat)	Standard gear
15	Bumpers	Steel replacement unit
		Leather, built-up canvas, scrap belting, reclaimed rubber
16	Bumper, vestibule trap door	Felt, scrap belting
17	Bushings:	
	(*a*) Buffer stem	Fiber, steel
	(*b*) Compressor, condenser units	Felt, wood
	(*c*) Insulating and nonabrasive	Fiber, composition, glass
	(*d*) Lamp socket	Fiber, plastic
	(*e*) Safety arm	Reclaimed rubber; impregnated cotton
	(*f*) Strain relief	Split plastic or wood
	(*g*) Torque arm	Reclaimed rubber; impregnated cotton
18	Buttons, snap-switch	Porcelain, plastic; use other type switches
19	Caps, cord grip	Plastic
20	Caps, polarized cord grip	Plastic
21	Cement, rubber	Eliminate wherever possible
22	Chutes, hopper	Metal tube with canvas extension
23	Coats, rain	Oil skins
24	Collar, cable insulating	Fiber, plastic; reclaimed rubber
25	Connection, flexible-duct	Chemically treated canvas
26	Control train parts for:	
	(*a*) Receiver-coil jackets, continuous	Impregnated coil, rope-covered
	(*b*) Receiver-coil jacket, intermittent	Linen-taped, compound impregnated, varnish-treated coil
	(*c*) Washers	Reclaimed rubber
27	Couplings, flexible	Leather; impregnated cotton; other types of joints
28	Covering, vestibule floor	Steel safety plate
29	Cups, driving	Steel springs
30	Cups, packing	Formed leather
31	Cushions, seat	Springs, hair, moss, felt, cotton
32	Device, centering	Wood
33	Device, centering	Steel rocker
34	Diaphragm, flexible	Canvas (accordion type)
35	Dies, rubber (slab)	Use other processes
36	Disks, generator driving	Solid metal disk
37	Disks, valve	Plastic, metal
38	Drive, flexible	Steel springs
39	Flooring	Carpet, linoleum, wood
40	Gaskets:	
	(*a*) Air-hose line	Discontinue use of units which require rubber gaskets and substitute pipe nipples and unions
	(*b*) Bellmouth	Plastic
	(*c*) Crossing-gate pulley box	Impregnated vegetable fiber
	(*d*) Fire hose	Leather
	(*e*) Garden hose	Leather
	(*f*) Headlight, marker and classification lamp	Impregnated asbestos
	(*g*) Headlight glass	Reclaimed rubber
	(*h*) Hose strainer	Impregnated vegetable fiber
	(*i*) Ice bunker	Felt or canvas
	(*j*) Ice-hatch plug	Felt or canvas
	(*k*) Marker-light lens	Putty or similar compound
	(*l*) Resilient mounting	Scrap belting or felt
	(*m*) Standpipe	Impregnated vegetable fiber
	(*n*) Tank-hose coupling	Fiber, wood
	(*o*) Tank-hose coupling nut	Fiber
	(*p*) Tight sealing	Impregnated vegetable fiber
	Gaskets (*continued*)	
	(*q*) Track-receiver coil cover	Impregnated rope, hemp, or cotton
	(*r*) Train-control equipment box	Impregnated fabric
	(*s*) Train-control junction box, plug coupler, relay	Impregnated fabric, impregnated vegetable fiber
41	Glazing strips	Reclaimed rubber; felt; putty
42	Grommets	Felt
43	Guards, splash	Felt
44	Handle, third-rail fuse-box-operating	Fiber
45	Hats, rain	Oil skins
46	Hose:	
	(*a*) Armored	Pipe and flexible metallic joints
	(*b*) Battery filling	Scrap hose; impregnated fabric
	(*c*) Cold water	Pipe and flexible metallic joints, (AAR Spec. EM 604–42)
	(*d*) Equalizing pipe	Pipe and flexible metallic joints if operating conditions permit
	(*e*) Fuel and lubricator	Pipe and flexible metallic joints
	(*f*) Oil (auxiliary force-feed lubrication)	Flexible metallic tubing
	(*g*) Oil (lines to stoker trough)	Eliminate
	(*h*) Pantagraph	Porcelain tubing
	(*i*) Safety guard spring	Scrap hose or other available covering
	(*j*) Steam	Pipe and flexible metallic joints
	(*k*) Tubing for rail wiring	Scrap hose or canvas
	(*l*) Tubing for train control	Scrap hose, flexible metallic tubing
		Circular loom tubing
	(*m*) Valve pilot	Flexible metallic tubing
47	Insulation, pipe	Coating of reclaimed rubber
48	Lamps, extension band (rubber handle, waterproof socket)	
	(*a*) General use	Wood or plastic handle, bakelite socket
	(*b*) Vapor and explosion-proof	Plastic
49	Lining, sponge rubber	Carpet or resilient material
50	Mats, floor	Wood floor racks; wire; composition
51	Matting:	
	(*a*) Ribbed or knobbed	Eliminate
	(*b*) Switchboard	Slatted wood; oil- or wax-impregnated matting
52	Mattresses	Coil springs with felt padding
53	Molding:	
	(*a*) Core, seat plush	Paper
	(*b*) Wainscot	Steel or composition
54	Mounting:	
	(*a*) Amplifier tube and ballast lamp	Metal springs
	(*b*) Axle light pulley	Reclaimed rubber; corrugated steel
	(*c*) Quill	Reclaimed rubber
	(*d*) Resilient, air-conditioning generator, and other mechanical equipment	Springs; felt
	(*e*) Resilient, blower fan	Reclaimed rubber; steel springs
	(*f*) Resilient, compressor box	Steel springs or omit
	(*g*) Resilient, relay supports and miscellaneous	Felt
	(*h*) Resilient, speed control	Steel springs
	(*i*) Torque arm	Reclaimed rubber
	(*j*) Valve support clamp expansion valve	Felt
55	Packing:	
	(*a*) Piston rod, ring, spiral and preformed	Impregnated asbestos
	(*b*) Rubber, cloth-inserted	Impregnated vegetable fiber
	(*c*) Rubber, solid	Impregnated vegetable fiber
56	Pads:	
	(*a*) Body center plate	Hardwood; steel
	(*b*) Body side bearing	Hardwood; fiber; leather; scrap belting; linoleum
	(*c*) Bolster stay rod	Steel wear plates; springs
	(*d*) Buffer stay rod	Coil steel springs
	(*e*) Buffer stem	Fiber; steel

(*Table 3 continued on page 571*)

TABLE 3 (*Continued*)

Name of part	Substitute
Pads (*continued*)	
(*f*) Carpet	Hair felt; paper
(*g*) Coupler centering device	Fiber; leather; scrap belting
(*h*) Foot pedal	Nonslip metal
(*i*) Insulating, roller bearing	Laminated wood
(*j*) Meter cushion	Scrap belting
(*k*) Spring clip	Plastic-bound fabric
(*l*) Spring plank stabilizer	Reclaimed rubber; coil springs
(*m*) Suspension	Reclaimed rubber; springs; scrap belting
(*n*) Thermostat	Springs, plastic; cork; felt
(*o*) Truck equalizer	Fiber; leather; scrap belting; oak; steel
(*p*) Truck spring	Hard or plywood steel
57 Sealing strip (loop, flat, tubular or molded)	Reclaimed rubber; felt
58 Seals, half round	Reclaimed rubber
59 Seats and lids, toilet (laminated wood core, rubber covering)	Eliminate rubber
60 Sheet rubber:	
(*a*) For packing and gaskets	Impregnated vegetable fiber
(*b*) For other purposes	Canvas or other waterproofed fabric
61 Shoe, curtain fixture	Plastic; metal; reclaimed rubber
62 Snubbers, bolster springs	Other approved types
63 Socket, weatherproof lamp	Bakelite
64 Standpipes, molded rubber parts for	Reclaimed rubber; molded leather
65 Stoppers, acid bottle	Reclaimed rubber; softwood
66 Stops	Leather; built-up canvas; scrap belting
67 Stops, door back	Backstops without cushions
68 Stops, hand brake lever	Scrap belting
69 Support	Steel springs
70 Switches, magnetic blowout, hard rubber parts for	Fiber
71 Tape, friction	Reclaimed rubber
72 Tiling, floor:	
(*a*) Car floors and washrooms	Linoleum; composition flooring
(*b*) Vestibules	Metal safety plate
73 Tires, solid rubber	Steel for manually operated trucks
74 Tops, table and counter	Linoleum; plastic
75 Treads, step (metal-inserted)	Perforated metal or subway grating
76 Valves, water pump	Plastic-bonded fabric
77 Washers, door hinge	Felt
78 Weatherstripping (loop, flat, tubular or molded)	Felt; waterproofed fabric; plastic

TABLE 4 RECOMMENDED REDUCED USE OF RUBBER; ASSOCIATION OF AMERICAN RAILROADS

Name of part	Recommendation
1 Accessories, plumbing (tank balls, fuller balls, floats, rubber elbows, washers, etc.)	Reduced rubber content
2 Air-brake equipment (check valves, gaskets, diaphragms, seats, seals, packing rings, and cups)	Reduced rubber content Compressed asbestos sheet
3 Batteries, storage and parts (hard-rubber container type; wood-tray rubber-jar type; other types)	Partial use of plastics, porcelain, and wood in place of rubber
4 Belting:	
(*a*) Rubber covered	Reduced rubber content
(*b*) Conveyer	Reduced rubber content
(*c*) V-type cog	Plain wrapped and molded-type belt
5 Belts:	
(*a*) Rubber, endless, flat	Reduced rubber content
(*b*) Endless V-section	Reduced rubber content
(*c*) Fan, V-type	Reduced rubber content

(*Table 4 continued in next column*)

TABLE 4 (*Continued*)

Name of part	Recommendation
6 Boots	Reduced rubber content
7 Cables, rubber-covered	Varnished cambric; braided asbestos; reduced rubber content; ASTM Emergency Alternate Specifications
8 Coats, all rubber	Reduced rubber content
9 Containers, air-activated cement, rubber parts for	Reduced rubber content
10 Cups, packing	Reduced rubber content
11 Diaphragms:	
(*a*) Trench pump valve	Reduced rubber content
(*b*) Control valve	Reduced rubber content
12 Forms, vulcabeston	Reduced rubber content; synthetics
13 Gaskets:	
(*a*) Blast cap and trap	Compressed asbestos sheet
(*b*) Boiler, manhole and handhole	Reduced rubber content in binder
(*c*) Booster	Compressed asbestos sheet
(*d*) Carbide lamp	Reduced rubber content
(*e*) Feedwater heater	Reduced rubber content
(*f*) Front end tape	Reduced rubber content in binder
(*g*) Magnet valve	Reduced rubber content
(*h*) Power reverse gear	Reduced rubber content in binder
(*i*) Smokebox door cover plate and stack	Reduced rubber content in binder
(*j*) Tight sealing	Compressed asbestos sheet
(*k*) Water tank attachments	Compressed asbestos sheet
14 Hose:	
(*a*) Air-brake and air-signal	AAR Spec. EM 601–42
(*b*) Air, gas and oxygen	AAR Spec. EM 603–42
(*c*) Air, long length	AAR Spec. EM 601–42
(*d*) Armored	Reduced rubber content; pipe with flexible metallic joints
(*e*) Armored	Reduced rubber content
(*f*) Brake cylinder	Reduced rubber content
(*g*) Cement container, air activated	Reduced rubber content
(*h*) Circuit breaker	Reduced rubber content
(*i*) Cooling system	Reduced rubber content
(*j*) Fire extinguisher	Reduced rubber content; scrap oxygen hose
(*k*) Fire, rubber-lined, cotton-jacketed	Reduced rubber content; unlined linen
(*l*) Fire, rubber-lined, cotton-jacketed	Federal emergency spec.; unlined linen
(*m*) Noncollapsible suction	Reduced rubber content
(*n*) Paint spray (air and liquid)	Reduced rubber content
(*o*) Sand discharge and sandblast, wire inserted	Reduced rubber content
(*p*) Tender tank	AAR Spec. EM 606–42; pipe with flexible metallic joints
(*q*) Third-rail shoe	Reduced rubber content
(*r*) Tubing	Reduced rubber content
(*s*) Vacuum-cleaning machines	Reduced rubber content
15 Insulator, Universal clip	Reduced rubber content: flexible plastic tubing
16 Liner, tender bed pedestal	Reduced rubber content
17 Lining, brake	Reduced rubber content
18 Mountings, quill	Reduced rubber content
19 Packing:	
(*a*) Compressed asbestos sheet	Reduced rubber content
(*b*) Piston rod, ring, spiral and preformed	Reduced rubber content
(*c*) Rubber, cloth inserted	Reduced rubber content Compressed asbestos sheet
(*d*) Rubber, solid	Reduced rubber content Compressed asbestos sheet
(*e*) Rubber, wire-inserted	Reduced rubber content
20 Rings, carrier guide	Reduced rubber content
21 Rings, hard-rubber, large bowl	Reduced rubber content
22 Seats, valve and gate rubber	Reduced rubber content
23 Tape, rubber	Reduced rubber content; varnished cambric
24 Tires, solid rubber	Reduced rubber content

(*Table 4 continued on page 572*)

Table 4 (*Continued*)

	Name of part	Recommendations
25	Toilets, valve seats, and washers	Reduced rubber content
26	Washers, washstand	Reduced rubber content
27	Wire, rubber-covered	Synthetic, varnished cambric, glass and asbestos insulation; reduced rubber content; ASTM Emergency Alternate Specifications

duced dividends in finding tools and tool steel. During one search, a stock of dies and shop tools was found which had been lost for years.

It is often difficult to differentiate between reclamation and repair. A substantial portion of the work which is done at reclamation plants is repair, but drawing a "fine line" is unimportant. One railroad saved $500,000, in 1941, at its reclaim plant excluding materials which were manufactured at roundhouses, shops, and other locations. Parts manufactured at the reclaim plant were valued at $65,000, a saving of $27,000, and 5000 net tons of scrap were used. Some of the work of reclaiming parts now being done is as follows:

New part	Old part reclaimed
Angle bars	Angle bars; planed for smaller rail
Bolts, engine	Bolts; cut shorter or turned smaller
Bolts, general purpose	Bolts; cut back and rethreaded
Bolts, machine	Brake beam rods
Chisels	Chisels; reduce length and re-use
Chisels, stone	Scrap springs
Crank pins	Engine truck axles
Crank-pin collars	Engine truck axles
Draft-gear keys	Engine truck axles
Follower plates	Engine truck axles
Forging billets	Scrap axles
Lumber	Lumber; larger sizes reworked
Nail-pulling bars	Scrap springs
Nuts	Nuts; larger sizes retapped
Packing hooks (journal box)	Scrap springs
Piston rods	Driving axles
Piston rods	Engine truck axles
Piston rods	Piston rods; larger sizes
Shafts, roadway equipment	Piston rods
Shovels	Shovels; reduce length and re-use
Springs, coil	Coil springs retempered and reset
Springs, elliptical	Elliptical springs; retempered and reset
Track tools	Track tools; change tolerance and re-use
Wrenches, S	Scrap springs
Wrist pins	Engine truck axles

MAINTENANCE AND SHOP PRACTICES

With replacement parts difficult to obtain, perhaps the workmen and supervisors will think twice in taking care of what they have. This may require a "new order" in inspection, maintenance, and shop practices. A little ingenuity will often keep a part in service that might be removed under less difficult circumstances. As long as the practice is safe and conforms to regulatory requirements it is justified under present conditions. For example, a one-thickness shim might be used on a loose driving-box brass to correct it for further service. In securing the maximum life from existing parts, it is important that full use be made of the limits of wear.

The proper lubrication of motors and shop machinery will prolong life. Excessive bearing wear is a cause of failure and frequent air gap gaging is a safeguard against this difficulty. Destroying parts by removal is a practice which can be eliminated in the interest of conservation. There are many cases where it may be cheaper because less labor is required to remove a part when it is destroyed, but often it is merely a matter of convenience. The deterrent to the procedure is the fact that parts are "hard to get" and the psychological effect of making this known is beneficial. Some practices may be questionable but they can be considered satisfactory provided the procedure is safe. Bolts, nuts, and pipe fittings are more generally subject to destruction when removed. In many cases, the latter may be usable where pipe pressures are low or the lines are in temporary service.

Shop practices have been based on the lowest production cost and have often resulted in wasteful material use. The situation has changed with respect to labor saving at the expense of material, since there will be no need for labor if there is no material on which to save labor. Machine tools have been classed among the greatest offenders and chips and shavings are poor melting scrap. Locomotive-valve stems and frame splice bolts are examples of excessive machining. The answer may be a return to greater use of forgings. A compromise forging is practical, suitable for any locomotive, weighing slightly over half a bar, with practically no difference in cost; forging plus machining. In the case of larger forgings, they can be roughed out under the hammer and finished more nearly to size with the torch at considerable material saving.

Another desirable practice is to use heavy-wall brass bushings to serve as rough stock for several finished bushings. This gives a high ratio of bronze borings sold to bronze purchased. The grinding of car wheels to remove flats, correct out of round, and eliminate built-up treads is advantageous. The amount of metal removed by this practice is just sufficient to restore the wheel to its original contour. If wheels are turned, the result is a loss of at least $^1/_{16}$ in. Modern welding practices are such that there are few castings which cannot be repaired for wear or cracks. Welding offers a multitude of opportunities to secure maximum utilization of existing parts by restoration to the original condition or correcting failures.

A good many practices have been introduced to reduce the demand on rubber. The wear of hose is less if care is exercised to avoid mechanical damage, burning, too high pressure, steam in other than steam hose, and delayed repairs. The provision of more outlets will require shorter lengths. Belts should not be allowed to slip or be subjected to exposure. Gaskets should be of the correct type and shape and prefabricated rather than cut from sheet.

Reclamation and repair are closely associated and much of the former work is done in railroad shops. Convenience is a factor, and many needed parts will naturally be reconditioned in shops rather than at the reclaim plant. Such practices are components of the over-all program and there is no need for segregating all phases of the activity. The important thing is to see that every available part which can be used is put in condition for re-use. In the control of maintenance practices, the shop has a means of establishing efficient material utilization. The determination of procedures which assure care in the disassembly of equipment will contribute substantially to the reclaimed-parts stock pile.

CONSERVATION PROGRAM WILL PROGRESS

In the "all-out" plans to obtain maximum usage of scarce materials, the economics of the program has assumed a secondary position. The primary consideration is to determine what procedures will best conserve every scarce product needed in the war effort. Many recommendations have been made and their worth proved. However, there are hundreds of profitable ideas which still lie dormant. It is these ideas that are needed to step up production capacity. The conservation program—substitution, reduced use, scrap recovery, and improved maintenance, and shop practices—has shown very satisfactory results and it is to be expected that the future will bring further progress.

Converting FURNACES *From* OIL TO COAL FIRING

Application of Conversion Methods to Boiler and Metallurgical Furnaces

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THE reasons for converting from oil to coal firing are well known, and we are now facing the problem of how best to convert under present conditions of shortage of critical materials.

For some years many people have recognized the advisability of installing boiler units so designed that they could burn oil or pulverized coal, whichever was the cheaper fuel or the most readily available; or, if the burning equipment for only one fuel was installed initially, to design the furnace so that it would be suitable for conversion to the other fuel with a minimum of changes. The advantages of this policy are clearly apparent at the present time when many plants have already been forced to discontinue burning oil and many more will have to do so in the coming months.

Completely water-cooled furnace units, such as the integral-furnace boiler and similar designs, have met these requirements very well, and many of these units have been converted to pulverized-coal firing with a minimum of furnace changes and little or no reduction in capacity.

Slag-tap pulverized-coal-fired furnaces of the larger sizes, as used in utility and the larger industrial plants, are equally suitable for oil or pulverized-coal firing, and where oil has been available they have been designed for use with either fuel, and present no problem at this time.

Pulverized-coal-fired units of medium and small size are not suited to liquid-ash removal, and to remove the ash in a dry form sufficient water-cooied surface must be installed in the furnace to reduce the furnace temperature below the softening temperature of the coal ash.

Water cooling in oil-fired furnaces is justified largely by the reduction in maintenance obtained thereby. Many furnaces designed for firing oil only have some water-cooled surface, but usually it is not adequate for firing with pulverized coal at the same output. On the other hand, any furnace suitable for firing pulverized coal can be fired with oil at the same maximum output as with coal.

The dimensions of a furnace are governed somewhat by the burner clearances required, but the volume of the furnace alone has little effect on furnace temperature and the commonly used unit, "liberation" in Btu per cubic foot per hour, is actually only a measure of the time the fuel and air are in the furnace. The best unit for obtaining a relation between the amount of water cooling and furnace temperature is the "heat available" in Btu per square foot of water-cooled surface per hour. The heat available is the heat in the fuel burned, plus the heat in the preheated air, less the latent heat of the water vapor in the products of combustion. In other words, it is the useful heat available for producing radiant heat.

TYPICAL FURNACE CONVERSIONS

Fig. 1 shows two integral-furnace boiler units which have been converted from oil to pulverized-coal firing by the installation of pulverizers and burners, with no changes to the furnace and there was no reduction in the capacity of the units. The capacity for each arrangement is as follows:

	Oil	Pulverized coal
Steam capacity, lb per hr	120000	120000
Heat available, Btu per sq ft of water-cooled surface per hr	81800	79600

The arrangement of the units in the building did not provide an ideal location for the pulverizers, due presumably to the prospects of conversion being considered remote at the time the initial installation was made, but fortunately the boiler units were so designed that they were suitable for pulverized-coal firing. This installation illustrates clearly the adaptability of pulverized-coal firing to difficult and unconventional layouts.

Other types of furnaces designed originally for oil firing only may require more extensive changes when converted to pulverized-coal firing.

Fig. 2 shows the conversion of a Stirling boiler installation from underfeed-stoker firing to oil firing in 1931, and a recently proposed conversion from oil to pulverized-coal firing.

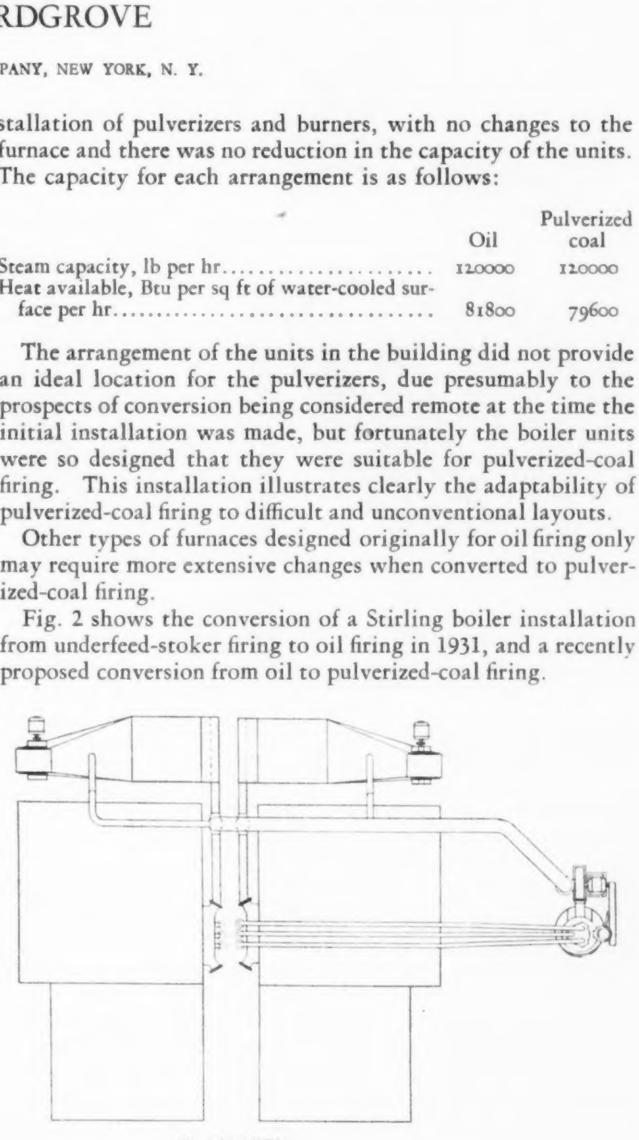


FIG. 1 INTEGRAL-FURNACE BOILER CONVERSION

Presented at a Joint Meeting of the Fuels and Steam Power Divisions, Metropolitan Section, New York, N. Y., March 22, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

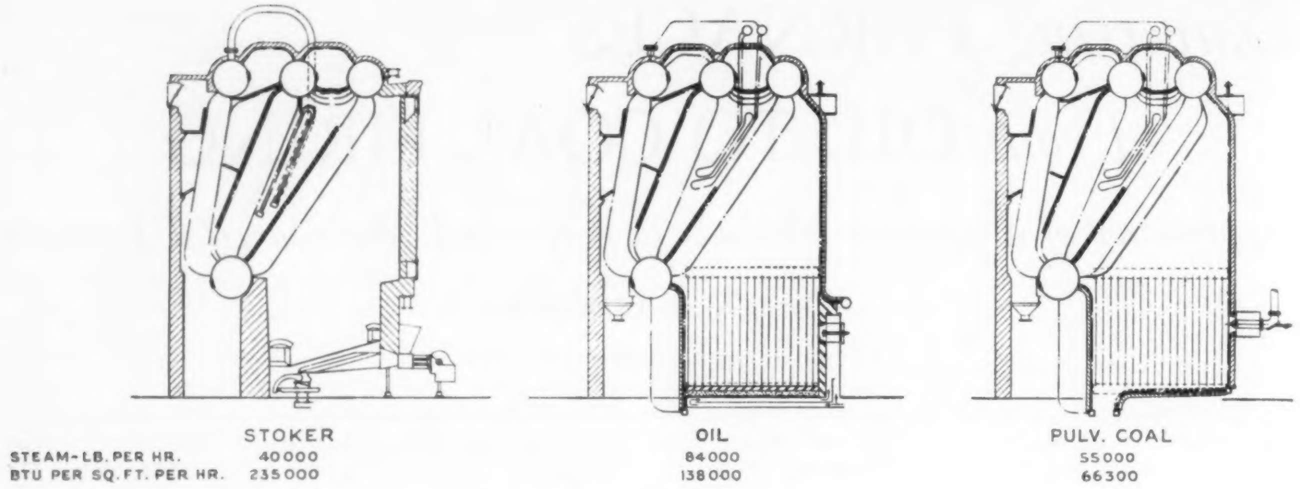


FIG. 2 STIRLING BOILER CONVERSION

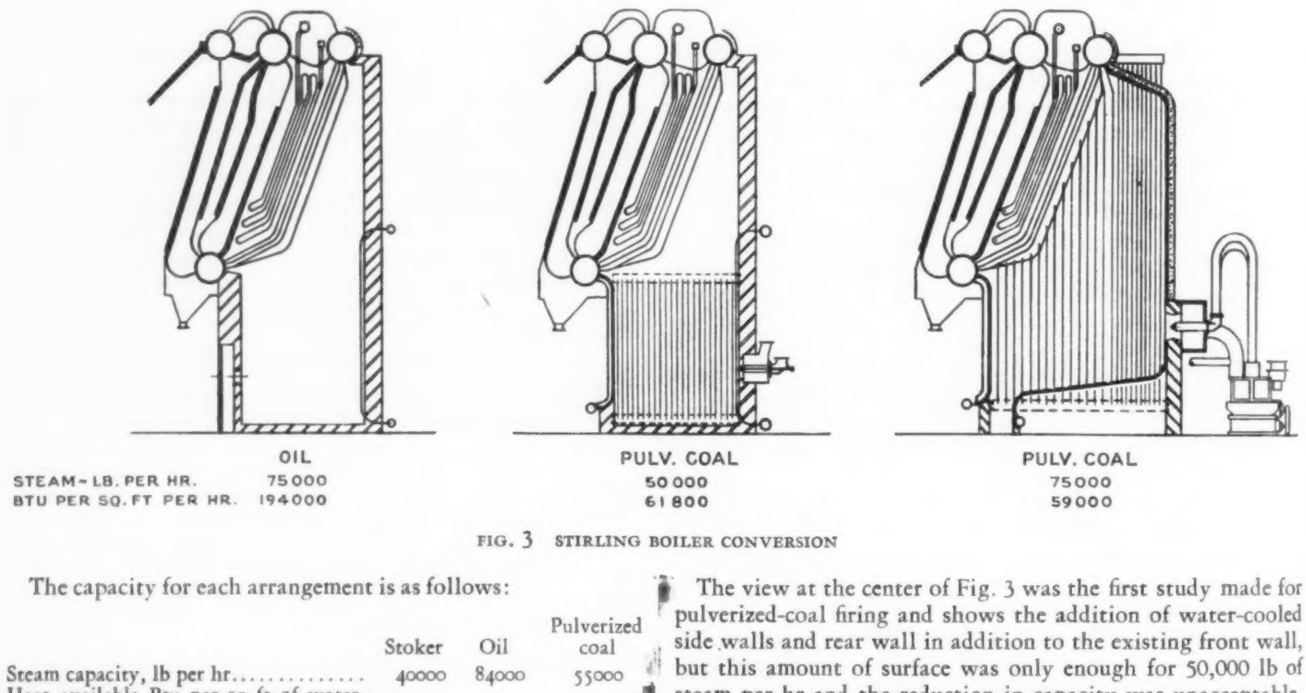


FIG. 3 STIRLING BOILER CONVERSION

The capacity for each arrangement is as follows:

	Stoker	Oil	Pulverized coal
Steam capacity, lb per hr..............	40000	84000	55000
Heat available Btu per sq ft of water-cooled surface per hr................	235000	138000	66300

It will be appreciated that in the foregoing table the heat available of 235,000 Btu per sq ft of water-cooled surface per hr with stoker firing is not comparable to the heat available with pulverized-coal firing, due to the large proportion of the heat developed in the fuel bed. The relatively low steam capacity of 40,000 lb per hr with stoker firing was limited by the restricted fuel-bed area available in the setting. Some water cooling was added when converting from stoker to oil firing, resulting in a large increase in capacity above that obtained with stoker firing being made available. When converting to pulverized-coal firing, essentially all the water-cooled surface possible without enlarging the furnace will have to be installed, and even then it will be necessary to reduce the capacity appreciably to prevent slagging.

Fig. 3 shows the conversion of another Stirling boiler, the capacity for each arrangement being as follows:

	Oil	Pulverized coal, Design 1	Pulverized coal, Design 2
Steam capacity, lb per hr...........	75000	50000	75000
Heat available Btu per sq ft of water-cooled surface per hr..............	194000	61800	59000

The view at the center of Fig. 3 was the first study made for pulverized-coal firing and shows the addition of water-cooled side walls and rear wall in addition to the existing front wall, but this amount of surface was only enough for 50,000 lb of steam per hr and the reduction in capacity was unacceptable. The view at the right shows the second design in which the front wall was moved out 5 ft and the furnace completely water-cooled, which provides enough water-cooled surface to operate the unit at the same capacity as with oil firing.

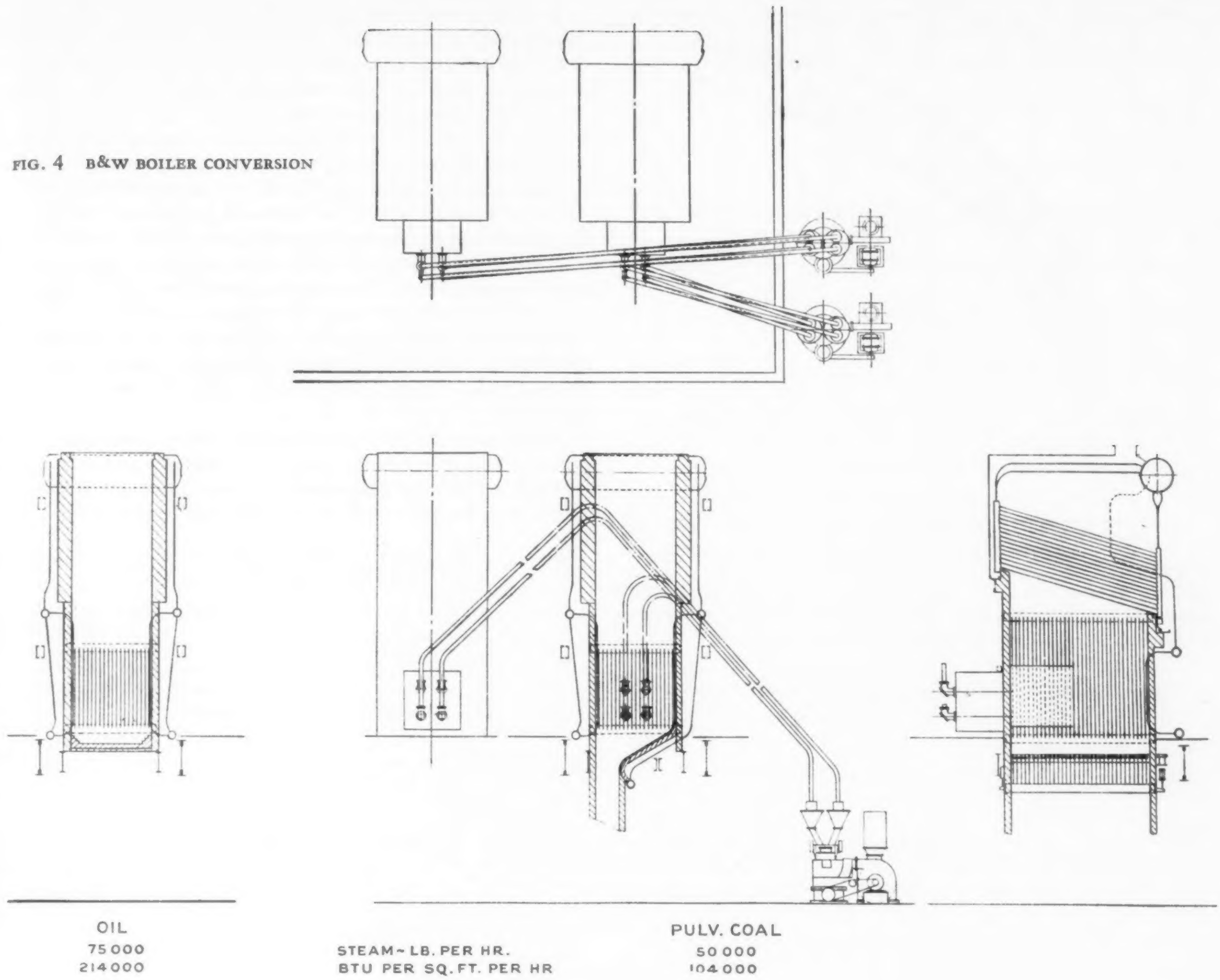
Fig. 4 shows a B&W boiler conversion. The capacity for each arrangement is as follows:

	Oil	Pulverized coal
Steam capacity, lb per hr....................	75000	50000
Heat available Btu per sq ft of water-cooled surface per hr..............................	214000	104000

These units originally had the sides and rear wall water-cooled for oil firing and the water-cooled floor was added on conversion to pulverized-coal firing. Even with the additional water cooling and using a relatively high-fusing-ash coal, a reduction in capacity is necessary to avoid slagging difficulties.

As is seen from the foregoing examples, a reduction in capacity is sometimes necessary when converting from oil to coal firing unless extensive furnace changes are made or unless high-fusion-ash coal, if economically available, is burned. Fig. 5 shows the reduction in capacity necessary on a group of conversions. The integral-furnace boilers, comprising eleven of the fifteen plants shown were the first to be converted as they re-

FIG. 4 B&W BOILER CONVERSION



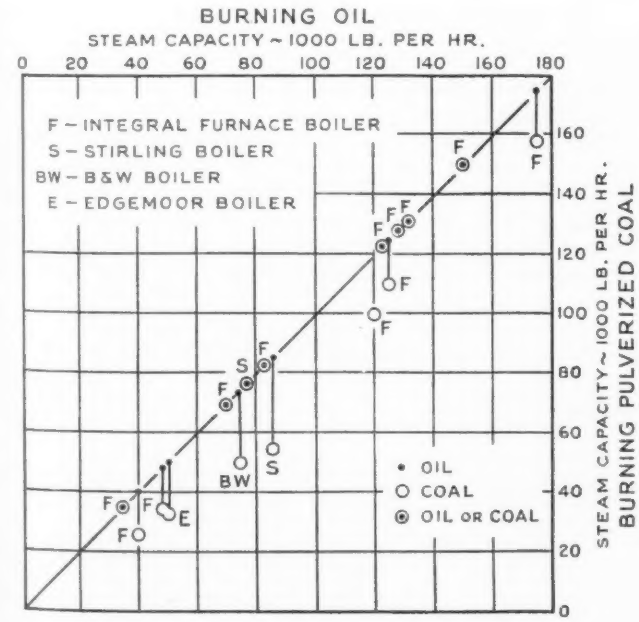


FIG. 5 CAPACITY BURNING OIL OR COAL

quired few changes to obtain little or no reduction in capacity. Units requiring more extensive changes, such as those shown in Figs. 2, 3, and 4, will no doubt form a larger percentage of conversions from now on, although involving greater cost.

Fig. 6 shows the furnace-exit temperature as measured by multiple-shielded high-velocity thermocouples on a large number of actual pulverized-coal-fired installations plotted against heat available in Btu per square foot of water-cooled surface per hour. The shaded bands represent the range of the test points and, while the band is quite wide, it represents variations in type of load, excess air, types of surface, and particularly a large difference in degree of cleanliness of the surface. The central portion of the band is, however, a starting point for estimating the amount of water cooling required for coal of a known ash-softening temperature.

In Fig. 7, the softening temperature of the coal ash is plotted against heat available for a number of actual conversions. The points plotted are the softening temperature determined on the usual reducing basis. The softening temperatures determined on an oxidizing basis[1] are considerably higher on ash having a high iron content and represent the oxidizing conditions of the actual furnace more accurately, but are seldom available at the time studies are made. When such information is obtainable on the coals available, the design can be established more accurately. The limits of the dry-ash-furnace temperature band from Fig. 6 are added for comparison.

For operation with dry-ash removal, it is desirable for the majority of these conversion jobs to install ample water-cooled surface in the furnace, to insure operation at the desired capacity when operating with coals of lower ash-softening temperature.

[1] "Significance of Coal-Ash Fusing Temperature in the Light of Recent Furnace Studies," by E. G. Bailey and F. G. Ely, Trans. A.S.M.E., vol. 63, 1941, pp. 465–477.

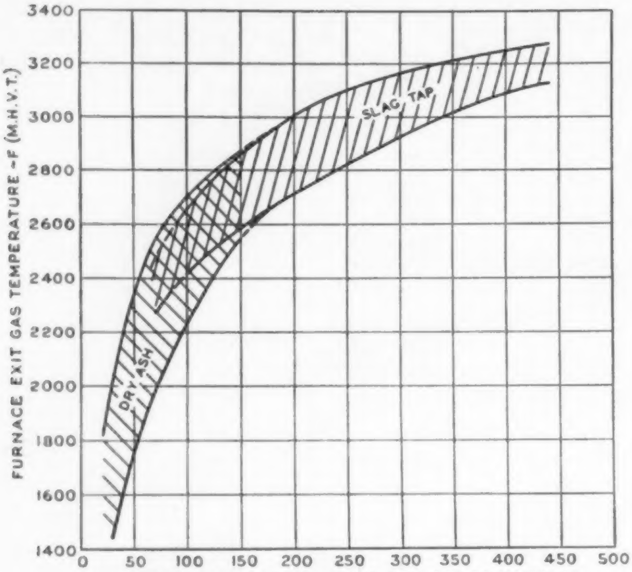


FIG. 6 RANGE OF GAS TEMPERATURES LEAVING COAL-FIRED FURNACES OF BOTH DRY-ASH AND SLAG-TAP TYPES AT DIFFERENT RATES OF HEAT INPUT

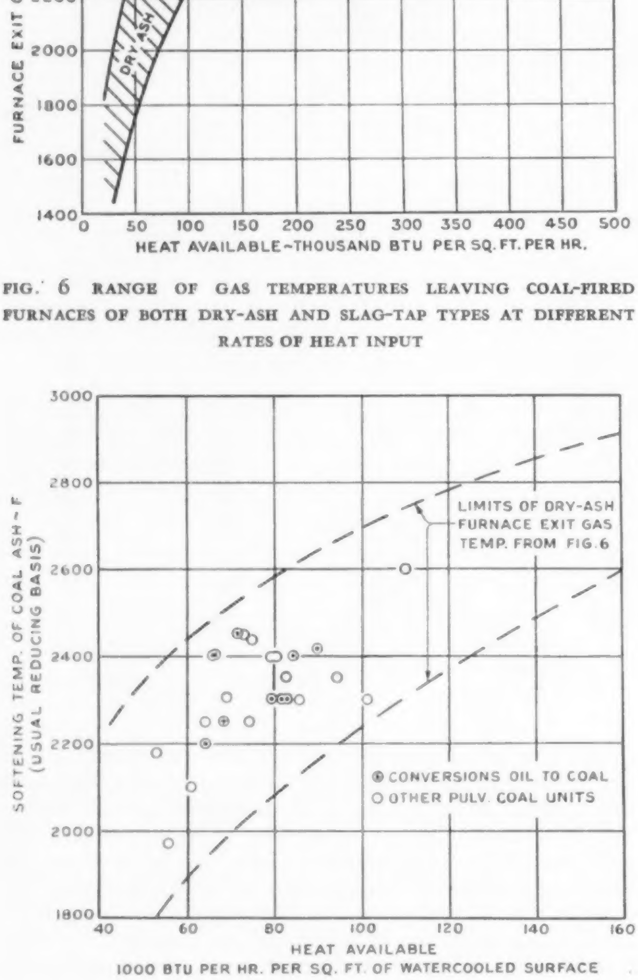


FIG. 7 APPROXIMATE RELATION BETWEEN SOFTENING TEMPERATURE OF COAL ASH AND HEAT AVAILABLE ON FURNACE DESIGNS FOR PULVERIZED-COAL FIRING

CONVERSIONS ARE NOT TEMPORARY EXPEDIENTS

There is an inclination to consider conversions as being purely temporary wartime expedients and to make them too cheaply, with the result that there have frequently been some operating troubles. The war has been primarily the cause of the restrictions on fuel oil, but it has also made us keenly aware of the importance of fuels and the necessity for conserving oil for vital purposes. The only safe procedure is to assume that oil as a fuel may never again be as plentiful or as favorable in price as it was before the war and to plan all conversions as permanent installations. There may be cases where shortage of materials will not permit making the type of installation at this time which should be made, but the design should be so planned that the additional equipment required to give a trouble-free job can be added as soon as material is available.

A well-known method of reducing furnace temperatures below those giving trouble from slag or other difficulties is by recirculating some of the flue gases and bringing them into the furnace, as shown diagrammatically in Fig. 8. This was first applied in arriving at proper temperatures in lime kilns and has since been used in oil stills and similar furnaces where limiting the maximum furnace temperature was necessary.

This same principle is applicable to keeping the temperature of boiler furnaces below the softening temperature of the ash. In fact the same effect has been obtained extensively for a long time by using a large quantity of excess air, as before water-cooled furnaces were used it was common practice to run with excess air up to 60 per cent. This additional excess air is more effective in cooling the furnace walls and floor if it is introduced through well-located ports as tertiary air, rather than being merely added through the burners with the required air for combustion.

An example of the application of the recirculation of flue gases to the water-cooled furnace of a boiler unit is given in Table 1. The arrangement of the furnace considered was far from ideal, but the values are nevertheless illustrative.

TABLE 1 DATA FROM RECIRCULATION OF FLUE GASES IN WATER-COOLED FURNACE

	Oil, refractory floor	Water-cooled floor: Pulverized coal, no recirculation of flue gases		Pulverized coal, 27 per cent flue gases recirculated
Column	1	2	3	4
Steam capacity lb per hr	70000	70000	52000	70000
Heat available Btu per sq ft per hr	115000	101000	75000	101000
Excess air, per cent	20	20	20	20 + 27 Flue gases
Furnace temperature, deg F	2225	2550	2445	2180
Fan power, hp	32.7	35.3	21.7[a]	58.6
Efficiency, per cent	79	74.3	77.2[a]	74.1

[a] Reduced fan power and increased efficiency are due to lesser steam output.

As shown in column 2, changing from oil to coal firing, even with the addition of a water-cooled floor, would give a furnace temperature of 2550 F which may be too high for the coal being used. Reducing the capacity to 52,000 as in column 3 would give a furnace temperature still higher than is desired, but within possible operating range with high-fusing-ash coal. By recirculating 27 per cent of the flue gases, column 4, the temperature can be reduced to 2180 F at the same output as when

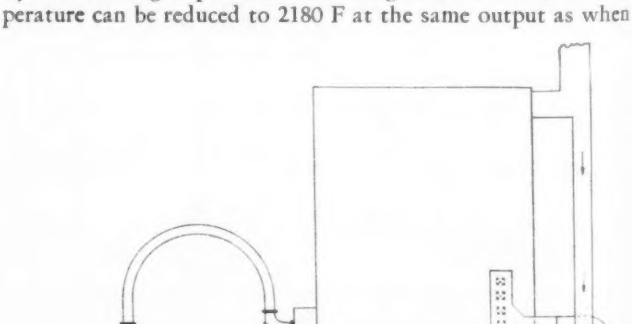


FIG. 8 DIAGRAMMATIC ARRANGEMENT OF RECIRCULATION OF FLUE GASES INTO A FURNACE TO REDUCE TEMPERATURE

firing oil and thus insure dry-ash removal and elimination of slagging troubles in the furnace. The additional fan power required for the operation with recirculation of flue gases is 23.3 hp.

In Fig. 9, the furnace temperatures for various percentages of tertiary air and recirculated flue gas are plotted against the heat available, based upon assumed conditions which are less favorable than the average. The top curve in Fig. 9(*A*) represents the furnace temperature with 20 per cent excess air at the burners and no tertiary air or recirculation of flue gases, and the lower dotted lines, the temperatures with tertiary air added. The solid lines represent the temperatures with 20 per cent excess air at the burners and various percentages of recirculated flue gases. From this plot it is seen that, whereas a furnace temperature of 2400 F would require a heat available of 75,000 Btu per sq ft of water-cooled surface per hr with 20 per cent excess air and no recirculation of flue gases, this same temperature can be obtained with a heat available of 150,000 Btu per sq ft of water-cooled surface per hr if tertiary air amounting to 15 per cent of the burner air plus fuel is used, or if 20 per cent flue gases are recirculated in addition to the 20 per cent excess air through the burners.

In Fig. 9(*B*) the efficiencies for the range of tertiary air and recirculated flue gas are plotted. The efficiencies with flue-gas recirculation remain fairly constant, as the reduced radiant-heat in the furnace and the reduced temperature entering the convection surface are almost compensated for by the higher mass flow over the convection surface. The efficiency drops when tertiary air is used as the weight of stack gases increases. The draft loss will be higher and additional weights of air and gas must be handled by the fans. The steam required to develop this additional fan power has been estimated and deducted from the gross-efficiency curves to obtain the net-efficiency curves shown. Under ordinary conditions, the cost of operating with the reduced output or the alternative of adding water-cooled surface where such addition is possible may be

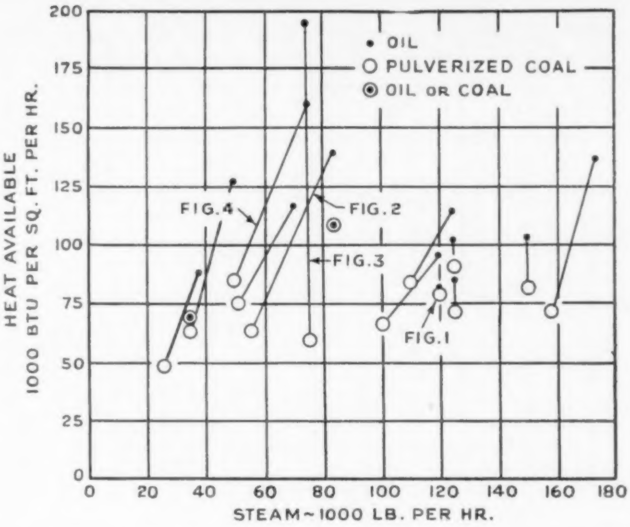


FIG. 10 REDUCTION IN HEAT AVAILABLE REQUIRED FOR CONVERSION

justified to avoid loss in efficiency, but under the present emergency, recirculation of flue gas may be the only way in which operation at the required capacity can be continued. The water cooling can be added and the recirculation discontinued when materials are available to make the installation.

In Fig. 10, the reduction in heat available required for conversion is shown. The large reduction in heat available with no loss in capacity for the unit shown in Fig. 3 was only possible by moving the front wall of the furnace out 5 ft and completely water-cooling the entire furnace. In other cases, the plant loads were such that a small reduction in capacity was not serious. In others the furnace was completely water-cooled and to add more would have required rebuilding the unit.

The dash lines in Fig. 11(*A*), show the weight of steel per pound of steam capacity required for the pulverizers, fans, feeders, burner piping, burners, and burner wind box for the average installation. The size of pulverizers varies with the grindability of the coal used as shown on the curve, and variations in ducts and piping may require more or less weight of material.

The plotted points in Fig. 11(*A*) are the weight of material per pound of steam capacity required for a group of conversions. These weights include pulverizers, burners, etc., and waterwalls where added, but no coal-handling equipment. The weight of material required for waterwalls varies widely with the specific installation and increases the total weight required as shown on the curve. The coal-handling equipment may require as much or more additional weight of steel than the pulverizers and burners and will vary widely on different installations.

Figure 11(*B*) shows the cost of equipment required per pound of steam capacity.

Oil-fired boilers in the group being considered will generally use 1 bbl of oil per year for each pound of hourly steam capacity if operated at 51 to 55 per cent annual load factor. The cost and weights in Figs. 11(*A*) and (*B*) can therefore be considered as being equal to the weight and cost per barrel of annual oil consumption if the units are operated at 51 to 55 per cent annual load factor, or the barrels of oil saved per boiler per year are equal to the steam capacity in pounds per hour. Adding the cost of erection and coal-handling equipment, the total cost may be more than double the values shown, but this is no reason for not converting.

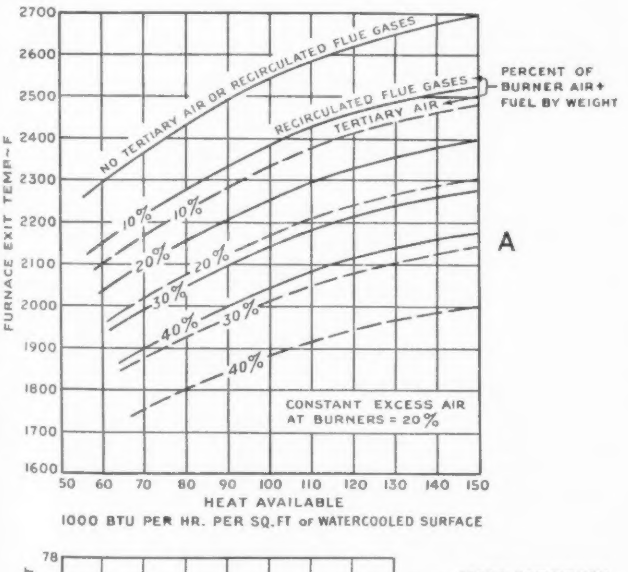


FIG. 9 REDUCTION IN FURNACE-EXIT TEMPERATURE AND EFFICIENCY BY RECIRCULATING FLUE GASES OR ADDING TERTIARY AIR

SAVING OIL IN METALLURGICAL FURNACES

Metallurgical furnaces are large users of fuel oil and present a considerable potential saving of fuel oil by conversion to pulverized-coal firing.

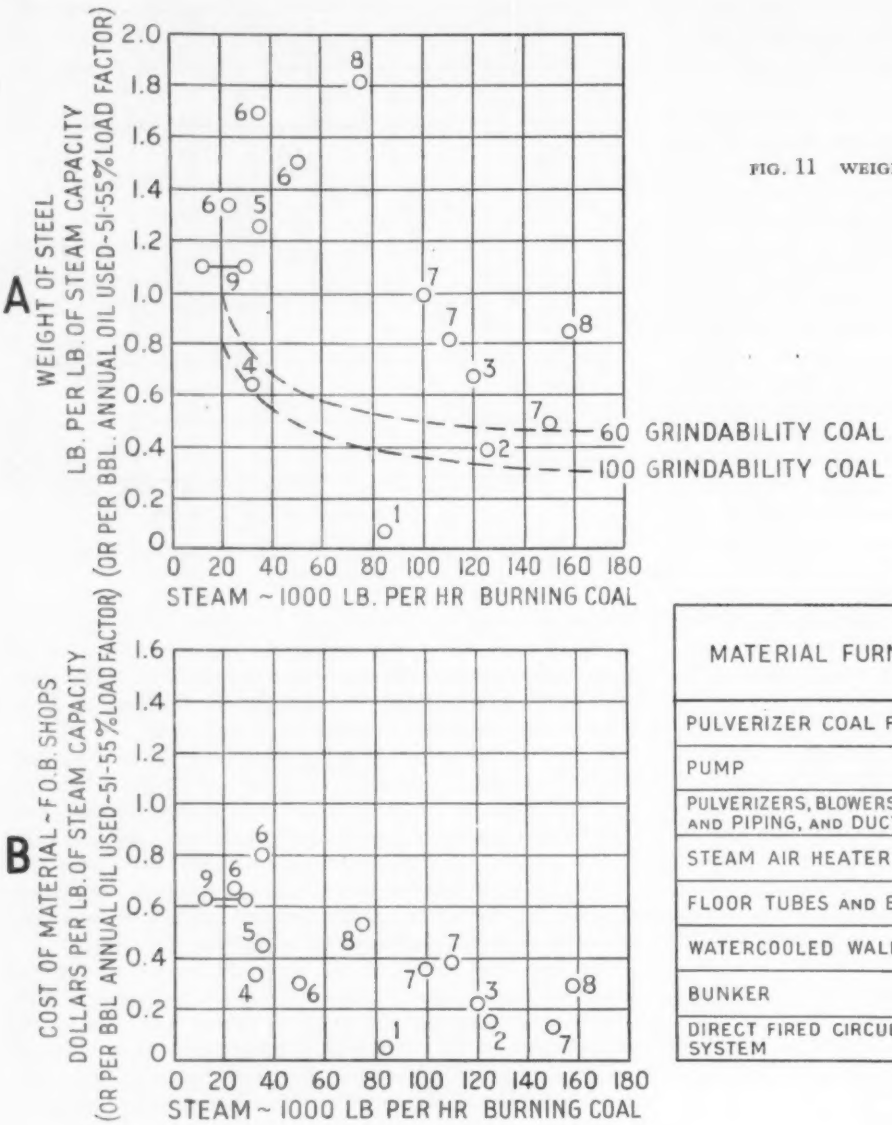


FIG. 11 WEIGHT AND COST OF MATERIALS REQUIRED FOR CONVERSION

MATERIAL FURNISHED	REFERENCE NUMBERS TO POINTS PLOTTED								
	1	2	3	4	5	6	7	8	9
PULVERIZER COAL FEEDERS	●	●							
PUMP		●							
PULVERIZERS, BLOWERS, BURNERS AND PIPING, AND DUCTS			●	●	●	●	●	●	●
STEAM AIR HEATER				●	●	●			
FLOOR TUBES AND BLOCKS						●	●		
WATERCOOLED WALLS		●						●	
BUNKER					●				
DIRECT FIRED CIRCULATING SYSTEM									●

The requirements of metallurgical furnaces fired by pulverized coal are as follows:

1 Careful selection of coal as to its ash characteristics.
2 Very high fineness of pulverization.
3 Uniform and controllable supply of coal and air to the furnace.
4 Furnace designs susceptible of being modified for satisfactory handling of the ash from the coal.
5 Flame with a high radiating characteristic and least tendency to oxidize the charge.
6 Conditions that will not increase the sulphur content of the metal being heated.

Metallurgical furnaces may be divided into two classes according to method of operation:

"Dry" furnaces in which the ash must be kept in a dry state, such as annealing furnaces, heating and forging furnaces, and soaking pits.

"Wet" furnaces in which the ash can be in a molten state, such as malleable melting furnaces, copper reverberatory and refining furnaces, open-hearth, and some types of ingot or bloom-heating furnaces.

The fact that many metallurgical furnaces have burned pulverized coal for years and are still doing so is proof that such difficulties as are inherent to the operation and which are primarily concerned with the handling of the ash in the coal can be overcome. Most of these earlier installations are fired by a

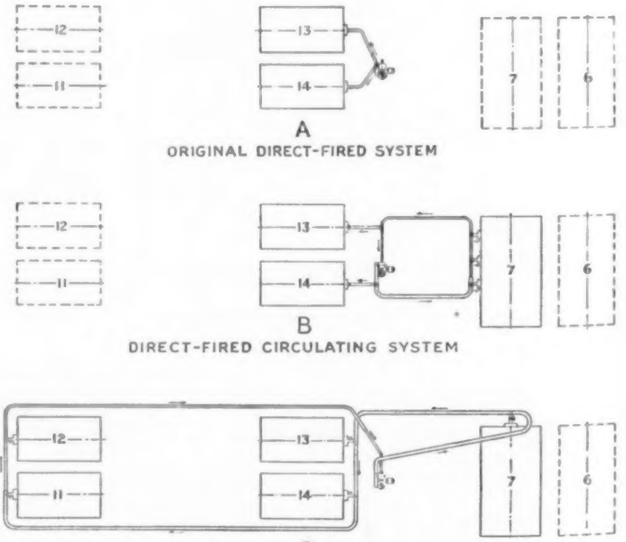


FIG. 12 DIRECT-FIRED CIRCULATING SYSTEM ON MALLEABLE ANNEALING FURNACES

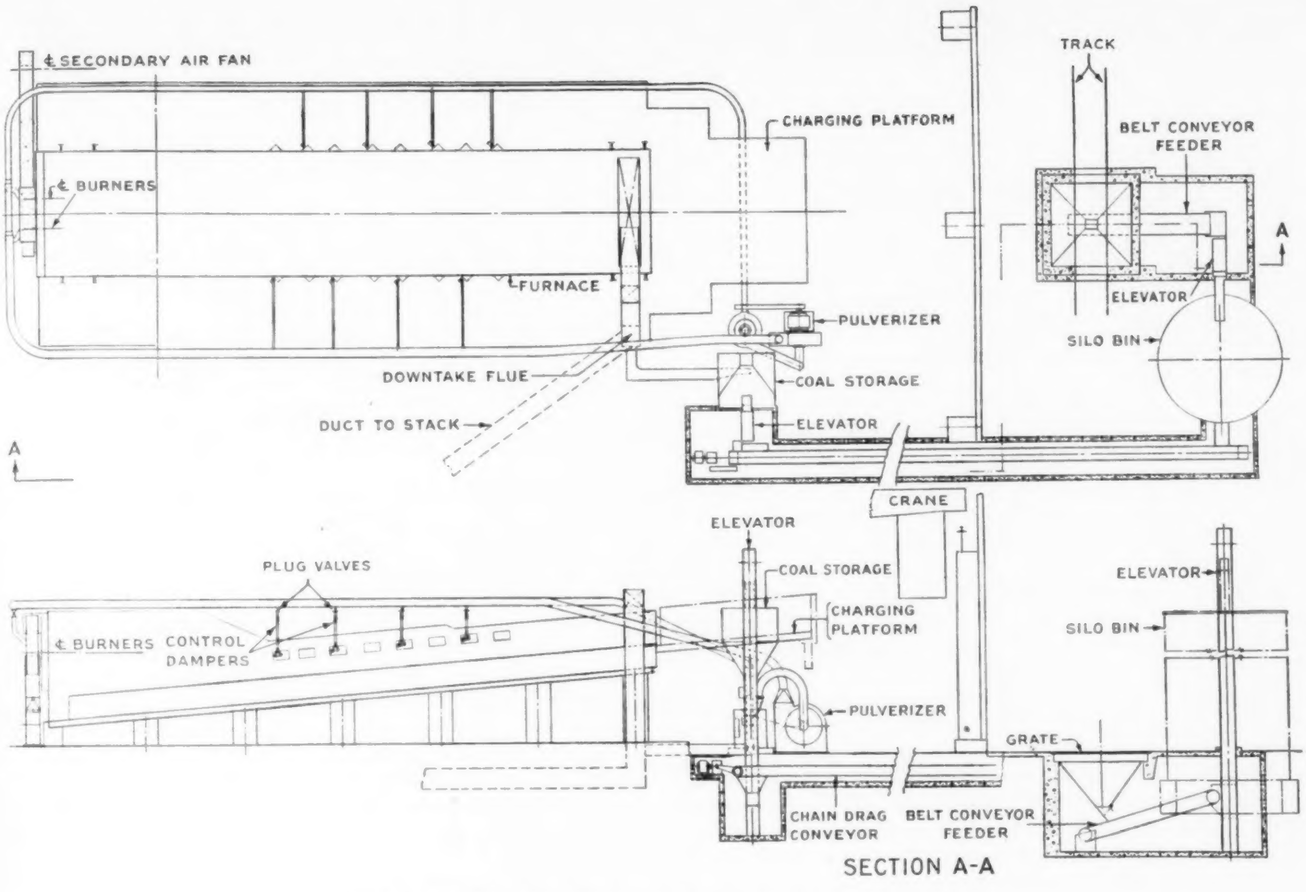


FIG. 13 DIRECT-FIRED CIRCULATING SYSTEM ON HEATING FURNACE

storage system and the coal is pulverized with types of pulverizers that cannot obtain a high degree of fineness. Also the pulverized-coal feeders in the storage system increase the packing action which occurs in the storage bin, with the result that snowballing of the coal particles occurs, which acts the same as coarse coal in the furnace. Many of the difficulties from slag particles on the product and from sulphur contamination are eliminated with very fine pulverization. Furthermore, direct firing which is practically universal in new installations in boiler plants and in increasing numbers with metallurgical furnaces not only eliminates all snowballing in the feeder and burner but also removes this source of coarse coal in the furnace.

SELECTING A SUITABLE COAL

The selection of the most suitable coal is an important factor in the successful firing of metallurgical furnaces with pulverized coal. High-fusing-ash coals are essential for dry heating furnaces operating at the higher temperatures where sticky ash is objectionable but are not necessary for dry furnaces operating at low temperatures, melting furnaces, and some heating furnaces which operate wet and tap out the slag. A medium or low sulphur content in the coal can also be obtained by careful selection, in fact much lower than is often contained in bunker C fuel oil. Low-ash coals are preferable but not necessary.

Copper reverberatory and refining furnaces have been successfully fired with pulverized coal for some years.

The firing of forge furnaces by pulverized coal has been described very completely by Engdahl and Graves.[2]

[2] "Pulverized Coal for Forge Furnaces," by R. B. Engdahl and F. E. Graves, *Heat Treating and Forging*, vol. 28, 1942, pp. 327–330, 336–338. "Performance Tests Prove Pulverized Coal Practical and Economical for Small Forge Furnaces," by R. B. Engdahl and F. E. Graves, *Heat Treating and Forging*, vol. 28, 1942, pp. 623–626.

PULVERIZED-COAL APPLICATION IN MALLEABLE-IRON-MELTING INDUSTRY

The malleable-iron melting-and-annealing industry has installed more pulverized-coal-burning capacity than other metallurgical industries, partly because the temperatures required are not so high, and ash-handling problems are consequently simplified.

Fig. 12 shows the development of an installation of pulverized-coal firing on annealing furnaces at a malleable plant. The initial installation, as shown at (*A*), was a standard direct-fired system, serving two furnaces. The pulverizer had a greater capacity than was needed for these two furnaces, and, as in their operating cycle they were off for considerable periods for charging and were also operated at low rates during part of the cycle, the proposal was made to use the same pulverizer also to fire an additional furnace, No. 7, which was equipped with hand-fired grates.

Fig. 12(*B*) shows the direct-fired circulating system as it was installed at that time to take care of any or all of the three furnaces.

In the direct-fired circulating system, the piping forms a complete loop with the mixture of coal and air being tapped off at each furnace as needed, a portion of the coal and air being carried on past the last burner and returned to the base of the pulverizer, where it is mixed with the hot make-up air supplied to the pulverizer. In this particular installation, the connections for each burner are made at the bottom of the loop line and a plug-type shutoff valve is located as close to the main line as possible. A butterfly control valve is placed below the plug valve and the line arranged as nearly vertical as possible from the plug valve to the burner. This system keeps an ample circulation in this single-pipe system at all times, irrespective of how many burners are in operation.

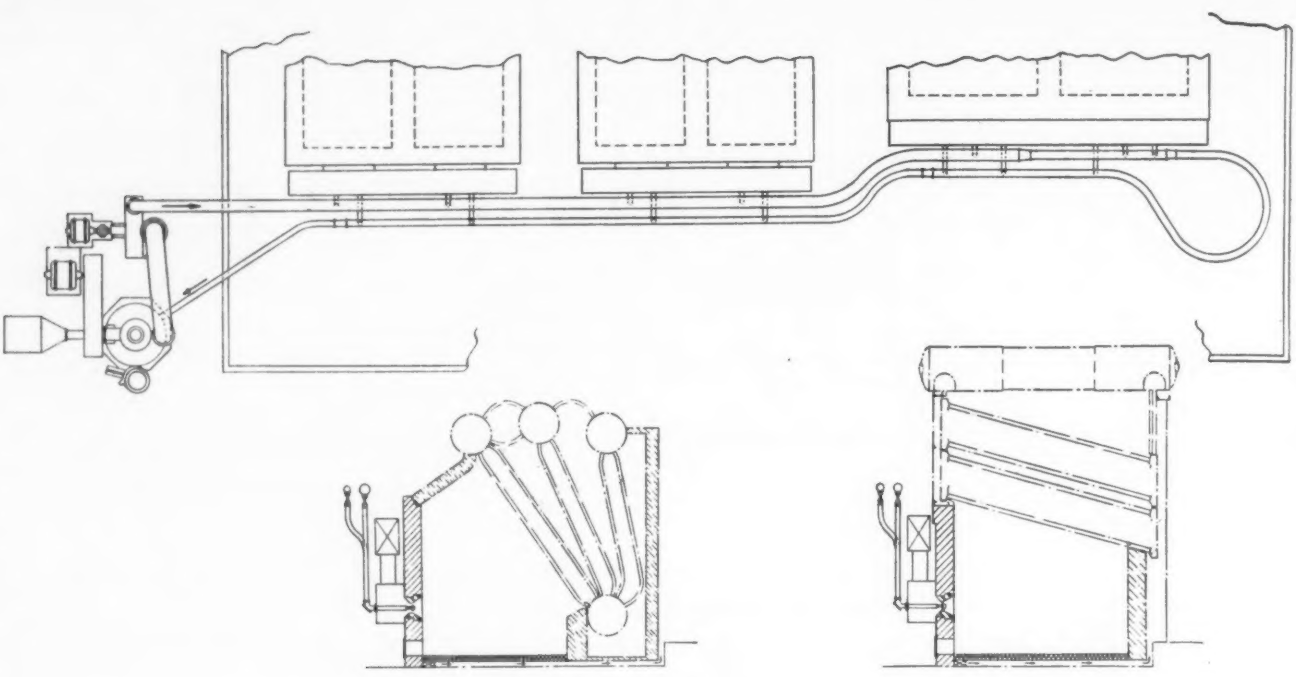


FIG. 14 DIRECT-FIRED CIRCULATING SYSTEM ON GROUP OF BOILERS

The installation, shown in Fig. 12(*B*), was in operation 11 months and proved to be so satisfactory that it was rearranged early in 1943 and extended to serve five furnaces as shown in Fig. 12(*C*). There are seldom more than four of the five furnaces fired at one time, and there are periods when only one furnace is in operation. A second pulverizer is to be installed to supply the remaining five annealing furnaces in the plant with a similar direct-fired circulating system.

BILLET-HEATING FURNACE IMPROVED BY CONVERSION

In The Babcock & Wilcox Tube Company's mill at Beaver Falls, Pa., a billet-heating furnace has been converted to coal which previously was fired with a combination of oil and gas. The average consumption was about 2400 gal of oil per day, burned through two oil burners at the end of the furnace, each burner having a maximum capacity of 60 gal per hr. Sixteen gas burners were arranged along the sides, having a total maximum capacity of 5870 cu ft of natural gas per hr. Because of space limitations, it was impossible to locate a direct-fired pulverizer near the large burners, so that the pulverizer was installed at the other end of the furnace and the direct-fired circulating system arranged to supply the two main burners at the end and four small burners on each side.

The installation is shown in Fig. 13. This billet-heating furnace uses about 1800 lb of coal per hr at 40 grindability and a fineness of 95 per cent through 200 mesh. As any sticking of the ash to the billets in the furnace is objectionable, care was taken to obtain coal from the Kanawha district of West Virginia, having a relatively high ash-fusing temperature and low ash and sulphur content. This installation has been in operation for a few months and the furnace conditions have been excellent, plain-steel and low-alloy billets being heated uniformly and with much less scale than when heated with oil.

Some sponge ash collects on most of the arch and falls to the floor, but this is not objectionable when the ash is dry. At one time several cars of coal of lower ash-softening temperature were received and the sponge ash on the roof became sticky. Upon dropping on the billets it gave some trouble in the rolling of the billets along the hearth, but closer control of the coal supply has eliminated this difficulty. Also, the underground flues were inadequate to eliminate a positive pressure in the upper end of the furnace and the installation of hoods over the furnace openings has been necessary to stop fly ash spreading over the room. With hoppers under each clean-out door to catch the ash removed during operation or at the week-end shutdown, the ash removal is a satisfactorily clean operation.

Most furnaces designed for oil will require some changes to take care of the ash from pulverized coal, but generally these changes are not extensive.

There are many small boiler plants which may be converted that have no available space for direct-fired pulverizers or coal bunkers in the present building and the direct-fired circulating system can be installed with the pulverizer located outside the boiler room.

Fig. 14 shows a boiler room with four Stirling and two B&W boilers. The total steam required is about 80,000 lb per hr and the coal is supplied by one pulverizer located outside the building through a circulating system arranged adjacent to the furnace. For this condition a very compact arrangement consists of a silo for raw-coal storage with the pulverizer located underneath. A track hopper and elevator constitute the only conveying equipment required and no building is needed for the pulverizer. The material for the pulverizer piping and burners is 1.15 lb and costs 63 cents per lb of steam capacity, which is less than a direct-fired-pulverizer installation and is very reasonable considering the small size of the units, namely, 80,000 lb of steam per hr from six units.

The direct-fired pulverized-coal circulating system is best suited for firing a number of small furnaces and particularly where conditions are so crowded that it would be difficult to install a direct-fired pulverizer for each one or two furnaces and supply them with raw coal.

Direct-fired pulverizers are still the best means of firing pulverized coal to medium and large steam and metallurgical furnaces, and the fact that the cost may be more than for the single pulverizer required by the direct-fired circulating system should not be the deciding factor if they provide the best permanent operating installation.

Thus it will be seen that each system has its own field of application. The two systems do not overlap or conflict but are complementary.

PROTECTIVE ENGINEERING *for Delicate* MILITARY EQUIPMENT

Principles Developed for Mounting Instruments and Other Vital Equipment in Planes, Tanks, and Ships

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THE characteristics of modern war are such that, despite the existence of destructive influences, sensitive apparatus plays a part in all important military operations, and proper protection must be provided to insure its accurate functioning. The prolongation of the life of such equipment under the punishment of constantly aggravating disturbances first entails provision of reasonable firmness in the equipment itself. An entirely separate and distinct, but not less important, approach to the same problem lies in the adaptation of effective cushioning mountings for the equipment.

Fundamentally, protective mountings applied to military or industrial equipment fall within either of two categories:

1 Those used to isolate, from the supporting structure and surroundings, disturbances originating within the mounted equipment.

2 Those used to support delicate equipment, protecting it from disturbances existing in the supporting structure.

Typical of case 1 are rubber suspensions used between the engine and plane structure on modern military and commercial aircraft. Illustrative of case 2 would be an instrument panel, radio, or bombsight, resiliently mounted within that same airplane. Case 1 has been quite comprehensively treated in recent technical papers. The present paper will therefore be largely confined to a consideration of case 2. It so happens that quantitative analysis follows the same fundamentals in case 2 as in case 1, although many of the factors that must be taken into account for adequate treatment are individual to each case.

STEADY-STATE VIBRATION AND SHOCK IN MILITARY EQUIPMENT

The types of disturbance from which protection must be provided are commonly known as steady-state vibration (referred to in the following discussion as simply "vibration") and shock. Vibration is recognized as being an oscillatory condition existing over an extended period of time, the characteristics of which are such that its amplitude plotted against time resembles a sine wave or can be shown to resemble several sine waves in combination. Common sources for this type of disturbance are main propulsion systems, auxiliary power plants, and rotating or reciprocating machinery, the vibration characteristics varying with speed of equipment operation and condition of loading for the most part.

A common source of such oscillatory vibration, in an Army tank lumbering along at steady speed, is the recurring contact of individual treads with the suspension "bogey" wheels and with the ground; wheel-driven vehicles may experience similar regular vibration from contact with seams in concrete pavement or the peaks of "washboard" terrain. Maneuvers of military craft and the common practice of operating over irregular ground can excite very aggravating shocks also. Moreover, impacts encountered in military craft can be of ballistic origin evidenced upon discharging guns mounted on the same equipment, or when that equipment becomes a target for enemy shells; torpedo hits and near misses, as well as mine explosions, are responsible for particularly violent shocks.

The isolation of forces which would destroy delicate equipment does not constitute the sole aim in adopting protective mountings, as it is common to come upon cases where the equipment is rugged enough to take it, from the strength standpoint, but where sensitivity of operation has to be preserved; this is particularly true of relays, circuit breakers, and voltage regulators, the contacts of which have shown evidence of opening or closing at a disadvantageous time due to disturbing influences.

Every resiliently mounted system has its own natural period of vibration, determining the frequency at which it will oscillate before coming to rest when subjected to a single impulse. Whereas such oscillation at natural frequency for a very short period of time is characteristic of the effect of shock, excitation of that same system by a source of steady-state vibration will cause oscillation of the mounted system at the rate of the impressed frequency.

As just mentioned, vibrations can be the result of vehicle operation over bumpy terrain, and, whereas the selection of most desirable mounts to isolate a predominant condition of vibration is often based upon procedure entirely different from shock protection, a logical question arises as to where the line is to be drawn between the two conditions of disturbance as frequency of impulses becomes lower and lower. The deciding factor in this matter is whether or not the mounted equipment comes fully to rest between successive impulses; if it does, the condition may be treated as shock, if not, vibration prevails.

A very significant consideration in all problems of protecting delicate equipment in military craft is the relative predominance of shock and of vibration as principal disturbing influences. Deliberately made to be as light as possible, consistent with strength requirements, an airplane spends the important part of its life off the ground and enveloped in air, a light fluid medium. Accordingly we concentrate upon providing protection of its equipment with particular respect to vibratory forces transmitted through the structure from its high-output main propulsion system, shock effects being of secondary importance. An Army tank, on the other hand, is of very great structural rigidity and is subject to a variety of impacts which could readily damage its equipment without incapacitating the vehicle proper; together with this requirement of shock protection is an equally important problem of isolating the tank equipment from vibrations originating in the main power plant and in the tracks, which latter condition is becoming increasingly serious with the use of steel instead of rubber treads. Large naval vessels represent another extreme, in that adequate shock protection must be provided relative to ballistic hits and explosive "near-misses," while vibrations from its heavy, slow-

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speed propulsion system are substantially less serious from a destructive standpoint.

PROTECTING AIRCRAFT-INSTRUMENT PANELS FROM VIBRATION

Concentrating for the moment upon vibrations typical of those treated as the problem in aircraft-instrument-panel protection, it is to be recognized that these may be of a translational or a rotational character. The resiliently mounted system itself has six degrees of freedom, and by this statement we mean that motion of a greater or less amplitude is possible in that many directions, three of which are of a translational form in separate planes, while the other three are of a rotational nature about three separate axes. When the word "freedom" is used in this sense it should be remembered that it is merely relative and accordingly that movement might be brought about with less effort in one direction than in another, depending upon the characteristics of individual installations. Moreover, the fact that a degree of freedom exists in a given direction does not by any means imply that forces or moments actually prevail to cause movement of that character.

If a body were free floating in space it is readily understandable that the magnitude of vibratory force reaching it from any outside source would be nil. Of course it is impossible to realize this ideal condition with a body mounted on a structure but, by attachment through soft mountings, it is possible to reduce transmitted vibratory effects very considerably. Naturally a resilient mounting will sustain a steady deflection due to the weight of the equipment supported; then, as vibratory impulses from the structure are brought to bear, an oscillating motion occurs on both sides of this statically deflected position. The effect of such vibration is to accelerate the mounted equipment in the instantaneous direction of the impulse, with the comparatively soft resilient mountings developing restoring effort as a state of strain is set up. But, before the distance through which the body has moved becomes very great, the vibratory effort will have changed its direction; accordingly the only part of the disturbing effort transmitted to the mounted equipment is that involved in deflecting the resilient mountings a distance corresponding to the maximum relative movement between that system and the structure.

It would be folly to attempt an analysis of vibration control without first recognizing the types and frequencies of vibration impressed upon the particular system under consideration. Having mentioned that adequate protection of instruments in aircraft installations requires extreme care, this will be treated as a specific case. Lacking 100 per cent accurate balance of rotating parts, the engine may be expected to excite translational vibrations at 1 times crankshaft revolutions per minute (i.e., "first order") in all directions in a vertical plane perpendicular to the crankshaft axis. Also predominant will be a rotational trembling of the engine about the crankshaft axis as the individual combustion impulses tend to rock the engine intermittently in a direction opposite to crankshaft rotation; occurring once every other revolution for each cylinder of a four-cycle engine, this would correspond to $4^1/_2$ order, or $4^1/_2$ times crankshaft speed, for a 9-cylinder engine. Analysis of the firing cycle will reveal a component occurring at crankshaft speed, which accounts for a first-order rotational vibration effect. Any misfiring cylinder in such an engine will create a power irregularity every other revolution, in which case $^1/_2$ order rotational vibration would be apparent. These several modes and frequencies of disturbance are known to occur simultaneously and continuously.

In aircraft engines the idling speeds may occasionally be as low as 400 rpm and on up to 800 rpm. Cruising and top speeds cover the range 1200 to 3000 rpm; in all cases the operating speeds for liquid-cooled engines extend into the higher part of the speed ranges. In terms of these rpm values and the awareness of the orders of disturbing vibration previously indicated, it is to be recognized that excitation may be encountered at from 400 to 800 cycles per min and from 1200 cycles per min upward, unless the $^1/_2$ order occurs due to misfiring, which will add a new low to the range. However, because the translational vibrations are inertia effects whose forces vary with the square of the speed and, because the rotational vibrations are not of great magnitude when the engine is not delivering power to the propeller, it has been found unnecessary to give great concern to vibrations at frequencies corresponding to low idling speeds. An expresion for the natural frequency of a resilient mounting system is

$$F_n = \frac{188}{\sqrt{D}} \qquad [1]$$

where D = static deflection (inches) existing in the mountings under the equipment weight supported, and F_n = natural frequency of the system (cycles per minute) in vertical translation. This formula can be applied to compute horizontal translational natural frequency as well by substituting in it an "apparent" deflection which is to be visualized as the amount the rubber would deflect if actually supporting the same equipment weight on a unit of stiffness corresponding to that prevailing in the horizontal direction.

The relationship between this natural frequency of vibration and the frequency of disturbing vibration from the engine is expressed

$$T = \frac{1}{\left(\dfrac{\text{Disturbing frequency}}{\text{Natural frequency}}\right)^2 - 1} \qquad [2]$$

where T is the transmissibility factor or that portion of the vibratory amplitude that is conducted through the resilient mountings to the supported equipment. It should be noted that solutions of T of less than, equal to, or greater than unity may result, but only when it yields a decimal value does vibration reduction occur.

Fig. 1 is based upon a comprehensive group of solutions to this formula in which the degree of vibration reduction may be observed by taking into account: (*a*) Frequency of disturbing vibrations from the engine; (*b*) static deflection in the mountings under the equipment weight supported. This clearly illustrates that, by an intelligent choice of static-deflection rating in line with the disturbing frequencies encountered, the possible degree of vibration isolation is tremendous. It may also be seen that, under certain poor combinations of conditions, the presence of the mountings may fail to reduce vibration transmission and may even aggravate or increase it; this latter case is known as "resonance" or "sympathetic vibration." When this occurs the natural frequency of the mounted system responds in step with the disturbing frequency of vibration from the engine theoretically causing the amplitude of vibratory motion to become infinite. Particular care should be taken to insure that resonant speeds, of which every resiliently mounted system has one for each degree of freedom, occur only when excited at an engine rpm below the operating range. If this is not entirely practical, it should at least be made to occur at a very low idling speed or a speed known to be transient, not a speed at which the engine may operate continuously, such as take-off rpm, cruising rpm, or top speed.

Fig. 2 shows one of six identical mounting points on the instrument panel of a current-model, two-engine, Army bomber, providing a convenient opportunity for the application of the chart, Fig. 1. This illustrates vividly the effectiveness of an arrangement known as a "double mounting," by virtue of which, upon using one mounting over the other in series with it, double deflection results. In this instance $^1/_{16}$-in. static deflection per mounting gives $^1/_8$-in. deflection per double mounting. With a disturbing frequency of 2400 cycles per min, corresponding to top speed, we find from Fig. 1 that about 95 per cent vibration isolation will result, so it is not surprising that

the movement of the panel is imperceptible to the camera, despite the fact that the vibration in the supporting structure is of sufficient amplitude to show a blurred effect in that part of the picture. It may also be deduced from the chart that vibrations at 1200 rpm cruising would be reduced by 75 per cent. Considering an idling condition at 600 rpm, the observation to be made is that, while no reduction has been accomplished with respect to any low-amplitude vibrations existing in this range, at the same time a resonant condition has been successfully avoided.

FIG. 2 AIRCRAFT INSTRUMENT PANEL USING TWO MOUNTINGS IN SERIES FOR DOUBLE DEFLECTION
(Note amplitude of structural movement which is isolated from the panels.)

Double-mounting installations, such as that illustrated, constitute a standard practice in the protection of instrument panels and other delicate apparatus in aircraft; a particularly desirable characteristic of this arrangement is that it can be so installed as to exhibit substantially equal stiffnesses with respect to horizontal and to vertical translation, by virtue of which the resonant-frequency band is held to a minimum and isolation is insured for all three translational modes.

Perhaps the question has arisen as to whether, say, vertical translational movement of a resiliently mounted body can be excited only by a vertical translational vibration from the source or, by the same token, if rotational motion can occur only as the result of rotational disturbance. Such would be the case if the mounted body were attached to the structure supporting that source in such a manner that its points of attachment were in a plane with its center of gravity. It has been observed, however, that delicate equipment to be mounted for aircraft service is actually so remote from the source of disturbance that the individual types of vibration tend to lose their identities, or become "coupled," as a result of which they do not reach the resiliently supported apparatus in their initial forms, translational disturbances predominating. Accordingly, it is necessary to assume that any degree of freedom of the mounted equipment can be excited by any mode of vibration from the source.

It is possible to compute the performance characteristics of a resiliently mounted system (even to applying a correction for unsymmetrical mounting location) before making actual installation and to check such calculations by attaching the system to a test stand and subjecting it to a variable-speed source of vibration. After sufficient tests have been made, changing the position of attachment of the mounted equipment from one test to the next, the natural frequencies of that system in each of its various degrees of freedom may be observed; and, if these are not compatible with the frequencies to be experienced in actual service, the resilient mountings should be altered to suit.

Fig. 3 shows such a test wherein the resonant frequency of a rubber-mounted body is in evidence. The table is driven by a rotating shaft through an adjustable double eccentric, providing means of varying amplitude as well as frequency or vibration. This is known as a "positive-displacement" exciter and contrasts with an unbalanced type of shake table, in that the latter contains merely a motor driving a deliberately unbalanced flywheel to shake the table as it rotates, in which design the magnitude of vibratory effect builds up as the square of the speed of rotation.

A reasonable "double amplitude," of oscillation for such a test would be $^1/_{64}$ in., comparing with 0.005 to 0.030 in. known to be conducted through aircraft structures. Experience has shown that the most sensitive apparatus is capable of standing up in aircraft service when its double amplitude of vibration does not exceed 0.004 in.

BASIS FOR SELECTING ANTISHOCK MOUNTINGS

It is time now to treat further the subject of shock, close destructive ally of steady-state vibration. Let us consider a structure which undergoes a sudden jolt or acceleration in response to an impact of external origin. As this occurs, the inclination on the part of a body resiliently mounted to that structure is to continue in a state of rest. If the mounting were so soft as to excercise no restraint whatever, and if sufficient clearance existed between that body and the structure, a large relative displacement could result and no part of the shock would be felt by the mounted equipment. By definition, however, a resilient medium will build up a restoring force under strain, as a result of which it inevitably experiences a degree of motion. With certain reservations, then, and proper consideration of all factors entering in, it may be stated that, for outstanding

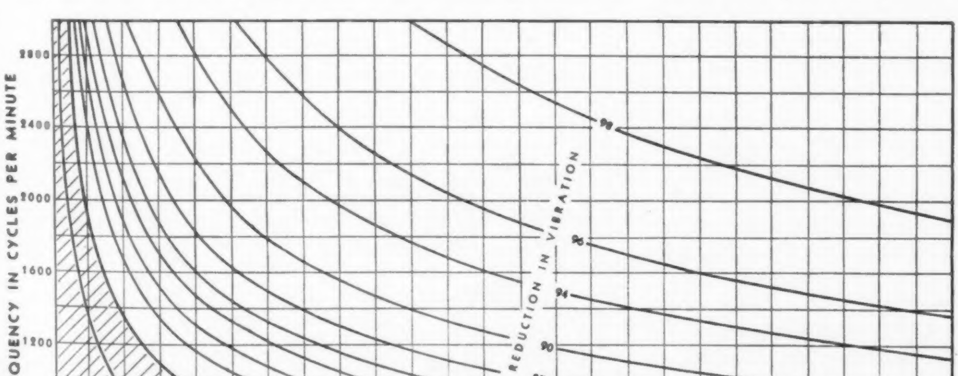


FIG. 1 MOUNTING EFFICIENCY IN TERMS OF DISTURBING FREQUENCY AND STATIC DEFLECTION

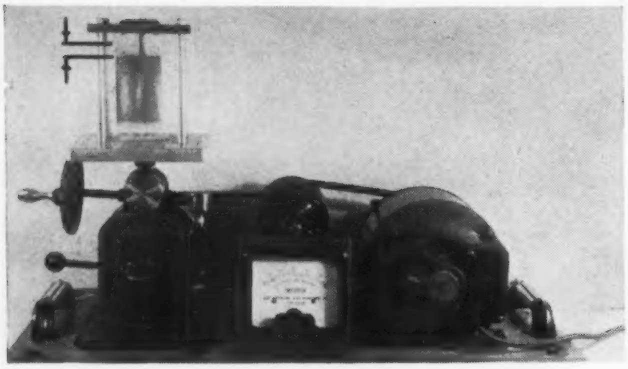


FIG. 3 POSITIVE-DISPLACEMENT EXCITER SET TO OPERATE AT NATURAL FREQUENCY OF RUBBER-MOUNTED BODY UNDER TEST
(Arrows indicate double amplitude of resonant vibration.)

shock protection, mountings should be chosen to be as soft as possible. This is consistent with the knowledge that the only force, and consequent acceleration, transmitted to the mounted equipment is that developed in the mountings as they deflect an amount equal to the relative displacement between the supported body and the structure.

Before choosing an antishock mounting for minimum stiffness, however, it is necessary to provide proper static deflection to satisfy all conditions of steady-state vibration that may exist at the same time. Moreover it is important to take care that undue instability of the mounted equipment relative to the supporting st ucture will not result, having allowed clearance to the extent of the intended unrestricted relative travel. It is a fact that in the selection of mountings to protect against shock, as well as in the control of regular vibration, extreme deflection beyond a reasonable degree fails to justify itself with appreciable additional protection.

The Tank-Automotive Center (Division of Army Ordnance Department), in co-operation with certain of its contractors, has carried on a large amount of shock test work. In the course of their projects, shells have been fired at production models of tanks and at turrets, each containing delicate equipment mounted on representative contrasting types of cushions. The shells used correspond to the most severe types fired against our tanks in warfare. Provision was made to insure that the projectiles would not penetrate but would spend 100 per cent of their kinetic energy at the impacted structure. In most instances, duplicate readings were taken of displacements, frequencies, and amplitudes of movements in the tank armor and various other elements. After each round a careful visual check was made to record damage occurring. Some pertinent observations have been recorded and all concerned feel aware of the necessity of giving attention to shock conditions as a fundamental requirement in mechanical development of military equipment.

Test records reveal that under impact the armor is subjected to very high-frequency motion of small amplitude, together with relatively low-frequency motion of large amplitude. It is evident that the frequencies apparent are natural frequencies and harmonics of the tank structural sections which have been excited by the impact just as a tuning fork can be set into motion. It must be recognized, however, that resonance does not exist, since the excitation is not continuous but practically instantaneous. While the high-frequency components are responsible for terrific accelerations that develop very great dedestructive forces in rigidly mounted apparatus, and thus create the principal need for protective mountings, the large amplitudes of the low-frequency components are cause for concern since they may result in exceeding the safe deflection limits of the flexible elements.

Fig. 4 shows diagrammatically the composition of the vibration excited, wherein B and C are the high- and low-frequency components which jointly constitute that shown as A. Considering either B or C individually, x_0 expresses the maximum displacement (feet), whereas x is the displacement after any time T (seconds), ω is the angular velocity of the motion (equal to cycles per second times 2π, giving radians per second). Such a sinusoidal relationship is analyzed according to expressions for simple harmonic motion as

(Displacement) $$x = x_0 \sin \omega T \quad [3]$$

(Velocity) $$\frac{dx}{dT} = x_0 \omega \cos \omega T \quad [4]$$

(Acceleration) $$\frac{d^2x}{dT^2} = -x_0 \omega^2 \sin \omega T \quad [5]$$

Since acceleration is expressive of the destructive force that prevails, we are principally concerned with that quantity. Substitution in Equation [5] indicates that this reaches a maximum value equal to $- x_0 \omega^2$. Solutions of this expression are commonly divided by 32.2 fpsps, enabling reference to accelerations as some multiple times g, i.e., times acceleration of gravity. High values of acceleration, as great as several thousand g, may exist in the structure, but these are not of great significance when considering forces affecting resiliently mounted equipment. It must be recognized that no accelerations anywhere near the peak figures prevail over a sufficiently long time interval to permit that amount of relative motion to occur which would develop correspondingly high restoring forces in the flexible elements. Actually the structure will have changed its direction of motion before very great relative motion occurs.

In terms of Equation [2], the ratio between disturbing frequency (from the structure) and natural frequency (of the resilient mounting system) is sufficiently high to give a low transmissibility factor, when considering the high-frequency components, while some higher, though not necessarily unreasonable, solution will result when substituting the lower-frequency components of structural vibration. The benefits of a resiliently mounted installation over a rigid system in the presence of these influences is obvious.

BALLISTIC IMPACT TESTING OF TANKS

Typical of the higher-frequency oscillations just mentioned

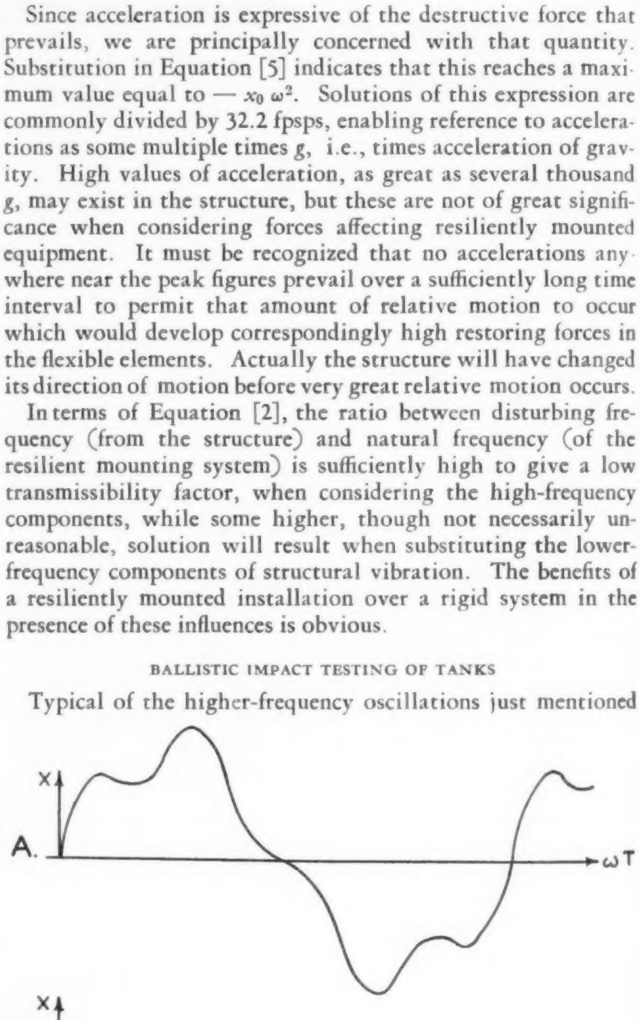


FIG. 4 COMBINATION WAVE A REPRESENTS HIGH-FREQUENCY WAVE B SUPERIMPOSED ON LOWER FREQUENCY WAVE C, EACH HAVING ITS OWN MAXIMUM SINGLE AMPLITUDE OF MOVEMENT x_0
(x indicates direction of positive displacement; T indicates time axis.)

was that set up in the hull of a light tank during ballistic impact testing, when a 9000-cycle-per-min disturbance was recorded under the fire of a gun similar to that used as the principal weapon on American light tanks. Accelerations caused by terrain shocks and gun recoil do not exceed $4g$, usually falling in the range of $2^{1}/_{2}$ to $3^{1}/_{2}g$. In a case where definite information is available as to the degree of acceleration that a piece of equipment can withstand without damage or faulty operation (which we believe should be at least $10g$ if ballistic impact is likely to be encountered), and where records indicate the magnitude of vibratory forces impressed on that body by the structure, there is wisdom in adopting mountings of such stiffness that the force transmitted to the mounted system is just safely incapable of causing damage or unsatisfactory operation. Such a choice would be made in an instance where unnecessary softness had to be avoided for reasons of stability, etc. In arriving at such a comp omise it should be borne in mind, however, that resonance produces much more severe accelerations at high frequency than at low frequency, should any possibility of resonance exist.

It has been agreed, on the basis of these tests on tanks, that instruments are incapable of measuring, and it is impossible to picture with any hope of accuracy, what happens at the point of ballistic impact or within a radius of at least 1 ft. To go a step further with this thought, it is known that the impact intensity of transmitted shock is reduced upon traveling through the armor, which is the basis of a recommendation to avoid attachment of equipment at positions on the tank that may be exposed to direct shocks by mines, bombs, or shell fire; the tank structure has an inherent capacity for shock isolation, of which advantage should be taken. By the same token, a greater benefit can be the result of mounting equipment on a comparatively flexible component of the tank such as the turret basket.

When it is impractical to avoid the mounting of equipment to the hull itself, there is said to be an advantage incident to the use of brackets allowing a degree of permanent deformation under close-by impacts, which yielding permits relative motion without increasing the force being transmitted; no part of the mounted equipment should be closer than 1 in. to the hull, since displacements of this magnitude can and have occurred under ballistic impact.

In particular connection with tank installations, reference must also be made to frequencies of steady-state vibration. Those emanating from the main power plant occur at substantially the same rate as disturbances in aircraft flight engines, while excitation from the tracks is from 1200 to 6000 cycles per min, depending upon the speed of the vehicle. On the basis of these figures, $^{1}/_{16}$-in. static deflection has been used for most rubber-mounted delicate equipment in tanks with favorable results.

HOW THE NAVY APPROACHES SHOCK PROBLEMS

The technicians of the United States Navy, particularly the Bureaus of Ships and Ordnance, have much experience behind them along the lines of shock research; their laboratories are well equipped for this work and they have at the same time consulted with industry in their anxiety to learn as much of the answer as possible. A much used Navy shock test is known as the 2000-ft-lb impact, in which a 500-lb weight falls 4 ft and strikes an anvil to which the equipment under observation is attached. A diagram of this test equipment is shown in Fig. 5.

Even more severe is a ballistic impact test in which the equipment is attached to the back of a heavy section of armor plate and 8-in. shells are fired at it. It actually has been found possible to use shear-loaded rubber mountings to protect apparatus from the impacts of 8-in. shells striking close by.

Even as in the other services, however, the Navy's problems are unique. To compete favorably in a technical type of warfare involves the adaptation of a very large amount of specialized apparatus. With installation space at a premium, due to very limited clearance in many ship locations, the Navy is constantly confronted with a problem entailing restriction of the over-all travel of certain antishock-mounted equipment. Consistent with a plan of providing protection from the most aggravating shock components encountered in naval vessels, without permitting unreasonable equipment travel, it is becoming common practice to select rubber mountings for static deflections of 0.010 in. or less, corresponding to resonance at a frequency above that impressed by the main propulsion system of the ship, which seldom exceeds 1600 cycles per min. In examining shock studies carried on by both of our principal military services, it is pertinent to note that the fundamental analyses of the Navy and their conclusions regarding the composition of shock are in agreement with those separately arrived at by the Army.

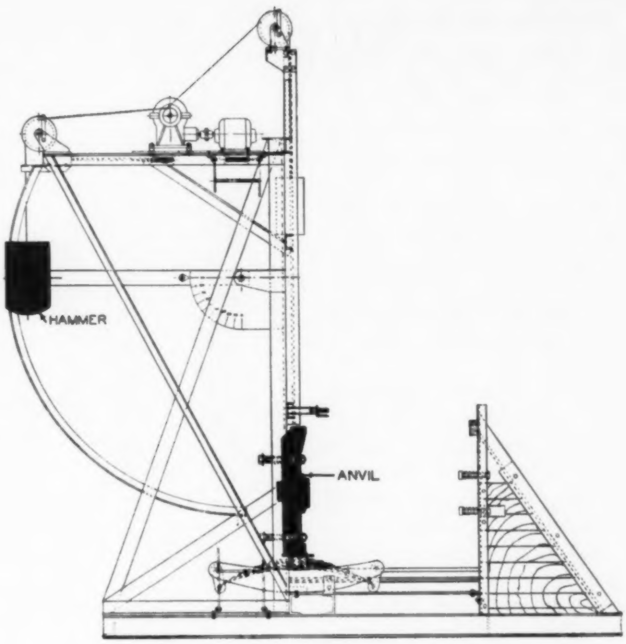


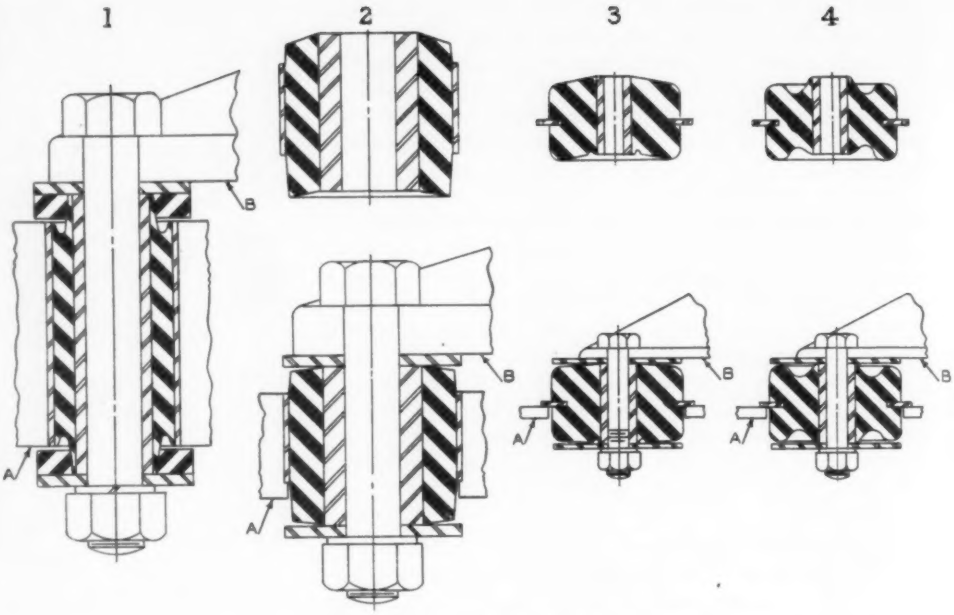
FIG. 5 IMPACT TEST OF 2000 LB USED BY U. S. NAVY
(Hammer is dropped on anvil, to which equipment under shock test is attached.)

"ISOLATION" AND "ABSORPTION" METHODS OF REDUCING VIBRATIONS

Two methods of reducing vibration transmission are those referred to as "isolation" and "absorption," and the difference between the two expedients is clear cut. "Isolation" implies the employment of resilient cushions which store vibrational energy during one part of a cycle and release it during a later phase. All of the foregoing treatment has been based on this principle. On the other hand a mounting is said to "absorb" vibration when it receives kinetic energy during all parts of the vibratory cycle yet releases none mechanically, converting it all to heat. Very often both these means are incorporated in the same system to accomplish vibration reduction jointly, as a shock absorber supplementing the spring of a vehicle.

Absorption is described as having a "damping effect" on a vibrating system and is capable of reducing the motion of the mounted system when the action of resilient elements would increase it, as in the case of resonance, transient effects, or rebound; at the same time, whenever the resilient mountings reduce the vibration, the damping effect detracts from the effectiveness of such reduction. A mild degree of vibration-absorbing capacity exists in rubber, on the order of 4 per cent of that which would be required to eliminate the vibration in $^{1}/_{2}$ a vibratory cycle, i.e., 4 per cent of "critical damping."

Fig. 6 shows the influence of damping on transmissibility. It should be noted that its effect is favorable at frequency ratios of less than 1.414, where more pronounced vibration magnification would otherwise take place, and unfavorable above that value, where more effective vibration reduction would otherwise result. The limited absorptive capacity in rubber is akin to fluid friction, the effect of which increases with the velocity of excitation, exercising negligible frictional restraint at the beginning of motion. Contrasting characteristics are exhibited by mechanical or dry friction which requires substantial effort to initiate motion and less effort to sustain it. The usefulness of this characteristic in an antishock or antivibration mounting is limited, since pronounced jolts are set up in overcoming the high initial friction and then that restraint decreases with further motion where it could be of greater benefit. The addition of absorption to a resilient support can, under certain circumstances, prove to be of benefit, but attention should always be directed to insure that all advantage has been taken of mounting stiffness best suited to existing conditions before increasing the damping effect.



A Members represent supporting structure
B Members represent supported equipment

FIG. 7 SNUBBING-TYPE MOUNTINGS

(1, Conventional tube-form mounting with separate snubbers. 2, Tube-form vertical snubbing mounting; upper, without load; lower, under normal load. 3, Sloping shoulder-type plate-form vertical snubbing, mounting under no-load and normal load. 4, High shoulder-plate-form vertical snubbing mounting under no-load and normal load.)

"SNUBBING" AS A MEANS FOR CONTROLLING VIBRATIONS

Frictional damping is not the only means employed in controlling large displacements due to impacts or resonant vibration in a sprung system. Another device in common use is that known as a "snubber," which has been built into mountings integrally, and in which case it is referred to as a "vertical snubbing" design. It became a justifiable matter of habit, in the course of working up mounting designs during peacetime, to adapt a vertical snubbing mounting for, say, a power plant in an automotive vehicle and to conclude that shock control had been provided. Actually this is an entirely different case from those discussed in this paper since the purpose in such nonmilitary installations is to limit over-all movement upon encountering road shocks with the sole aim of preserving alignment between driving and driven equipment, and between power plant and frame. Reduction of forces due to such impacts was not demanded of the engine mounts because chassis springs, operating at far greater static deflection, performed this function effectively.

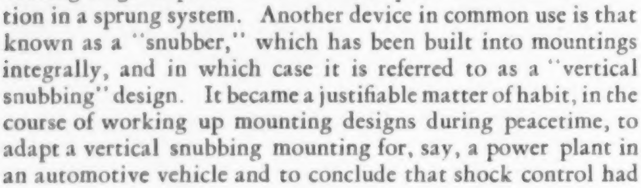


FIG. 6 RELATION BETWEEN TRANSMISSIBILITY FACTOR AND FREQUENCY RATIO

(Damping increases transmitted vibration in normal range of application, reduces it in amplification zone.)

Various commecial forms of snubbing-type mountings are shown in Fig. 7, all of which are proportioned to provide a small amount of travel for accomplishing vibration isolation within a predetermined working range and to limit over-all movement beyond that range. Fig. 8 is a typical load-deflection curve for this type of mounting, and it is to be realized that such a unit usually appears in a shape that is offset toward one end when not supporting load, in order that the application of its intended static load will bring it into symmetry with equal clearances adjacent to restricting surfaces at both "load" and "rebound" ends. Because the stiffness of the mounting is so much greater outside the working range, it is imperative that a snubbing-type mount be selected only on the basis of accurate knowledge of weight supported; an improper selection will almost inevitably result in poor isolation characteristics.

In a resilient-mounting installation without such snubbing provided by stiffness that increases with travel beyond a normal range, a large displacement can result in metal-to-metal contact of bracket members. Accordingly, it is usually desirable to set limits to travel, either early or late in the stroke, employing a stiff, though far from rigid, medium. An opinion shared by many persons experienced in this line indicates that the recommended travel in either direction before undergoing snubbing action should be 7 to 10 times the single amplitude of the most destructive high-frequency component of disturbance; at the same time this clearance should be at least equal to the amplitude of the lower frequency component. If it is found to be entirely impractical to provide an assembly according to this plan, because of space limitations (it is to be borne in mind that

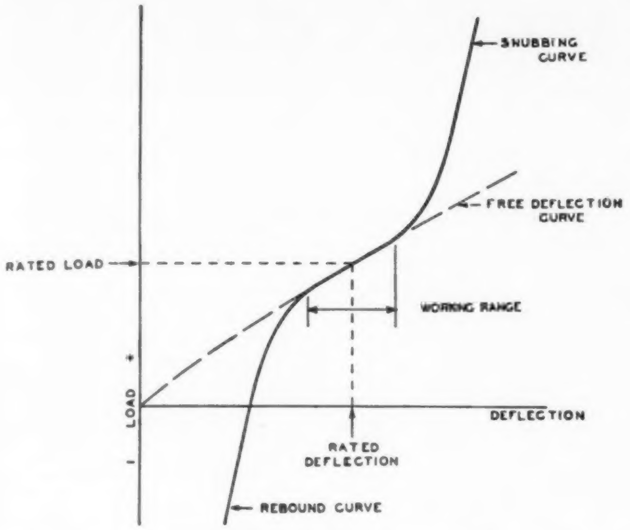


FIG. 8 TYPICAL LOAD-DEFLECTION CURVE FOR VERTICAL SNUBBING-TYPE MOUNTING

the safe travel for a rubber mounting is proportional to the rubber dimension being deflected), probably the worst alternative would be to incorporate snubbing at some shorter degree of travel. Such an arbitrary choice has been known to result in the magnification of vibratory forces due to the effect of blocking the movement of the system when its velocity is high. We feel that a decidedly better compromise than this is to incorporate far earlier snubbing action (which does not stiffen up sharply at any stage of deflection), in order to check the movement before high velocity can develop.

PRACTICAL CONSIDERATIONS FOR THE VIBRATION ENGINEER

In approaching a conclusion of fundamental references on this subject, there are a number of practical points which have been found advantageous. Particularly important is the advisability of locating mountings in either a horizontal or a vertical plane with the center of gravity of the supported equipment. In Fig. 9 sketches (*A*) and (*B*) illustrate the "do" and "don't," respectively, for installation of a given piece of equipment. The advantages of a "center-of-gravity suspension" are: (*a*) It substantially prevents different modes of vibration from becoming coupled; (*b*) The individual natural frequencies can be made to fall within a reasonably narrow range; (*c*) For a given stiffness of mountings this arrangement yields the greatest possible stability.

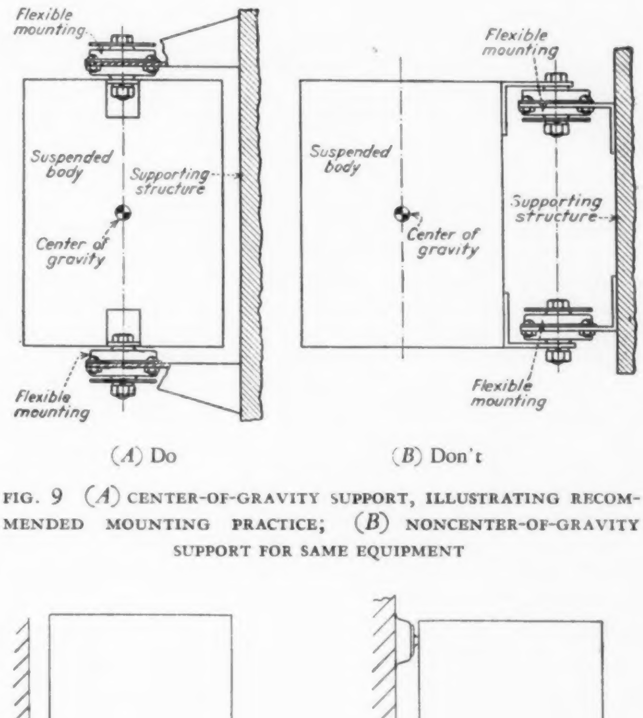
There is no question that rubber-mounting engineers would be in a position to extend greater service in devising outstandingly protected equipment installations if the attitude: "Here's a piece of apparatus; how shall we mount it?" were superseded by: "We are laying out a new device. What provision shall we make for rubber mountings?" Nevertheless, in the necessary haste of our present problems, we are often compelled to do the best we can with what exists. This fact has often been the reason for locating the points of resilient support at the base of a tall piece of equipment as in (*A*), Fig. 10. The stability of this assembly, with center of gravity high above the mounting plane, would be greatly improved by the addition of stabilizing mountings at the top as indicated in (*B*).

Sometimes an individual delicate element in an apparatus requires a greater degree of protection than can be provided within the over-all limitations of a resiliently mounted installation. This might be true of a particular radio tube in a set mounted at the cabinet base. An arrangement that has been applied to provide the required protection in such instances is the separate mounting of that single element as a unit. Having done this, the secondary mounting system is not expected to exhibit a natural frequency that can be anticipated solely in terms of its own static deflection, since the resilient supports at the base will also have a bearing on the combined natural frequency. Before freezing such a design, it is recommended that the complete apparatus be subjected to shake-table tests and that all mounting selections be fixed on the basis of the observations made.

The sources of the information upon which this discussion is based are many and it is the author's sincere hope that useful references may be extracted by others. If there is one particular point which requires special emphasis, it is the absolute necessity of basing the specifications of protective mountings on prevalent conditions. Casual selection can be disastrous and the practice of installing something similar to a rubber heel, with the hope that it will be better than nothing, is to be avoided.

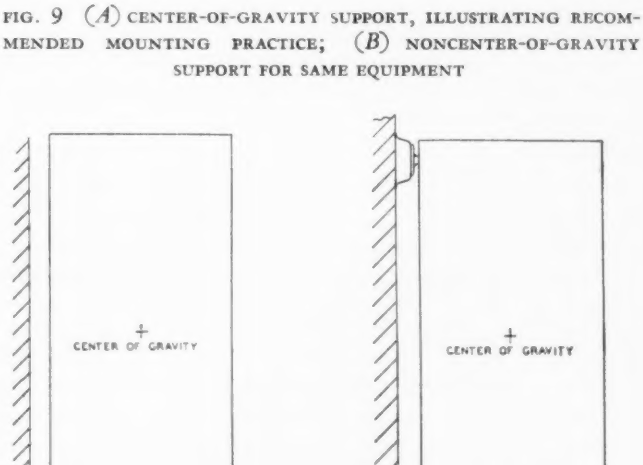
ACKNOWLEDGMENTS

To the Tank-Automotive Center of the United States Army Ordnance Department, to the Bureaus of Ships and Ordnance of the United States Navy, to the contractors of these organizations, and to Messrs. Leon Wallerstein, Jr., and Tom L. Yates of the Lord Manufacturing Company, acknowledgment and thanks are gratefully rendered for contributing to the contents of this paper.



(*A*) Do (*B*) Don't

FIG. 9 (*A*) CENTER-OF-GRAVITY SUPPORT, ILLUSTRATING RECOMMENDED MOUNTING PRACTICE; (*B*) NONCENTER-OF-GRAVITY SUPPORT FOR SAME EQUIPMENT



(*A*) Don't (*B*) Do

FIG. 10 (*A*) UNDESIRABLE, AND (*B*) DESIRABLE METHOD OF MOUNTING TALL EQUIPMENT, PROVIDING STABILITY

PROGRESS *in* SOCIAL SECURITY[1]

By ARTHUR A. BRIGHT, JR.

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TWO significant reports have recently been published in the field of social security, one in the United States and one in England. Although somewhat similar in purpose, there are differences between the reports in scope and development which reflect the situation peculiar to each country.

THE NATURE OF EACH PUBLICATION

The American treatise,[2] "Security, Work, and Relief Policies," a report of the Committee on Long-Range Work and Relief Policies to the National Resources Planning Board, is a broad intensive survey and evaluation of public aid in the United States from 1930 to 1940. As the most comprehensive study of this nature in the United States, much of the report is devoted to an explanation of the problem of economic insecurity, to the development and operation of remedial measures during the decade of the thirties, and to an analysis of the suitability of these programs. The report attempts particularly to formulate principles whereby existing policies and the provisions of current measures may be judged and to which prospective measures may be adapted. General recommendations are presented for all major aspects of an integrated program of social security.

"Social Insurance and Allied Services," a report[3] by Sir William Beveridge to the British Government, is a more narrow but more detailed study of a particular phase of social security, being devoted to proposing a specific plan for social insurance and allied services for adoption in the near future. An explanation and justification of the plan constitutes the entire body of the report. The need for public intervention in the achievement of social security and the operation and imperfection of existing schemes are assumed in the report, although some material relating to these matters appears in appendixes. Furthermore, in his report Sir William acknowledges the principles which have become accepted in Great Britain over the period of its experience with social insurance, rather than attempting to evolve a set of basic principles himself. In a sense, therefore, the Beveridge report picks up where the American report leaves off, projecting a social insurance plan carefully worked out in its most important details, whereas the American report lays down the general principles and framework within which a detailed program for all phases of social security may be constructed.

A GENERAL COMPARISON

Fundamentally, each report proposes enlargement and improvement of the existing schemes of social insurance for those risks which are common to large proportions of the population—sickness, accident, old age, and unemployment. In addition, extension of present forms of supplementary assistance and service is advocated in both cases, and a permanent but highly flexible public-works program is proposed for the United States.

The development followed in each report is natural in view of the experience of the two countries with problems of social security. In England the responsibility of the national government in providing social insurance and financial assistance for various types of individual want has long been recognized. Programs designed to meet all major classes of need have been in existence for considerable lengths of time. The Beveridge report was designed solely to point out how the system of social insurance and allied services should be co-ordinated and improved. It was not necessary that an extensive report of the American type be undertaken. Indeed, a general survey of this sort had been made in England as early as 1909.

In the United States the federal government did not accept a responsibility for social security until after 1930, and the measures taken up to 1935 were considered to be temporary to meet the existing emergency. Since 1935 more permanent developments have taken place, but they have not followed an integrated pattern. Accordingly, the committee's report to the National Resources Planning Board constitutes an attempt to guide future progress into an adequate, well-rounded, national system of social security.

Sir William Beveridge believes that there are three main requisites for security of the individual: (1) peace, (2) employment, and (3) the continuation of income when earnings are unavoidably interrupted. His report deals almost solely with the third requisite. The American report goes beyond that of the British, considering in addition the provision of employment by the public when private employers cannot furnish jobs for all who want them. It does not deal directly with the general problem of the business cycle and full employment, however.

An adequate comparison of the social insurance and public assistance provisions of the American plan with the Beveridge proposal cannot be made without considering the work-relief aspects of the Committee's report. The program advocated in each country is proposed as a unit and must be considered in this light. Although both proposals are designed to meet the particular situations existing in their respective countries and neither would be suitable for the other nation, Americans particularly will benefit from a knowledge of the British plan.

THE BEVERIDGE PLAN

The British plan is summarized in the Beveridge report as follows: "The main feature of the Plan for Social Security is a scheme of social insurance against interruption and destruction of earning power and for special expenditure arising at birth, marriage, or death. The scheme embodies six fundamental principles: flat rate of subsistence benefit; flat rate of contribution [by insured individuals]; unification of administrative responsibility; adequacy of benefit; comprehensiveness [with respect to risks insured]; and classification [of insured groups] . . . . . . Based on them and in combination with national assistance and voluntary insurance as subsidiary methods, the aim of the Plan for Social Security is to make want under any circumstances unnecessary."

The plan calls for classification of the population into six groups, as follows: (1) employees, (2) others gainfully occupied, (3) housewives, (4) others of working age not gainfully occupied, (5) those below working age, and (6) those retired above working age. It is proposed that each person in each group, regardless of his level of income, be required to pay a flat weekly contribution to cover the risks common to his

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "Security, Work, and Relief Policies." Report of the Committee on Long-Range Work and Relief Policies to the National Resources Planning Board. United States Government Printing Office, Washington, D. C., 1942, 640 plus xii pages, $2.25.

[3] "Social Insurance and Allied Services." Report by Sir William Beveridge, published in the United States by The Macmillan Company, New York, N. Y., 1942, 299 pages, $1.

class. Benefits would similarly be the same for everyone, based on the amount of income necessary for subsistence. This arrangement is in accord with principles accepted in Great Britain. Those individuals who desire more than subsistence incomes would, as at present, be encouraged to cover their risks by additional voluntary insurance to any desired amount.

An important provision of the scheme is that benefits should continue as long as they are needed, rather than ceasing after some statutory limit, on the theory that the need for aid increases rather than diminishes with time. Moreover, benefits are to be the same whether arising from sickness, unemployment, disability, or old age. The fact that earnings tend to be higher than the bare subsistence level will encourage the vast majority of workers to resume earning as rapidly as possible when they are temporarily not at work. The postponement of retirement will also be encouraged, which is considered desirable for Great Britain. In the case of unemployment, benefits will be paid for a limited period only, unless the individual attends a work or training center and accepts any reasonable employment offer.

Under the proposed classification, all occupations and groups excluded from existing schemes become covered, and special schemes are to be amalgamated into the general program. The administration of all these insurance provisions, as well as supplementary assistance on the basis of need for those who do not meet the specific eligibility requirements, is to be consolidated under a single Ministry of Social Security.

It is proposed that the plan be financed in the same manner as existing social insurance, by sharing the cost of security among three parties—the insured person, his employer, if he has one, and the state. The shares borne by each vary among the various types of risk, but the British believe firmly that contributions from individuals should be as great as is compatible with maintaining their purchasing power. They do not wish social insurance to resemble a public dole any more than is necessary.

The suggested supplementary allowances for children are designed to relieve the financial burden for those workers with large families, regardless of the parents' income. Even when earning, the parents are to receive allowances for all children but one. When work is interrupted, they are to receive an equal additional allowance for the remaining child. It is hoped that this will tend to raise the birth rate in England, which has declined alarmingly in recent years, as well as relieve the distress common to large families.

Although not dealt with in great detail, there are two additional assumptions in the Beveridge report which are fundamental to its success. It is assumed that comprehensive health and rehabilitation services will be made available to all individuals to minimize interruption of their earning power by sickness or accident. It is further assumed that every effort will be made by the national government to maintain employment and minimize interruption of earnings from lack of work.

RECOMMENDATIONS BY THE AMERICAN COMMITTEE

The American report emphasizes (1) the provision of work for all who are able and willing to work, (2) social insurance to maintain the income of those whose work is interrupted, (3) public assistance for those in need who do not come under either of the two foregoing programs, and (4) public provision of necessary community services where they are not otherwise available. The writers of the American report believe that the problem of public aid in this country is likely to be both large and persistent for some time to come. Accordingly, they have attempted to achieve a consistency among the various parts of a permanent and adequate system of social security.

Although the recommendations of the committee are much less detailed than those of Sir William and comparisons are consequently made more difficult, it seems that the American suggestions involve few more fundamental changes than the British plan. Strengthening and expansion rather than revision constitute the essence of the proposals. It is recommended among other things that federal work programs be continued on a permanent basis but with a high degree of flexibility; that special programs for youth continue; that the social insurances be extended in comprehensiveness, coverage, and adequacy of benefits; that public assistance be provided by the federal government; that special types of assistance be co-ordinated with the general program; that training and employment services be extended; and that the Federal Security Agency be given the status of an executive department responsible for the administration of most of the details of the program.

In its social-security provisions the report calls for new schemes of disability insurance, which are not now included in a general form in the United States, but it does not propose insurance against sickness. Provision of health service is, however, strongly recommended. The report proposes extension of coverage of unemployment insurance, an increase in size of benefits and in their duration, and replacement of existing federal-state systems by a wholly federal scheme. Old-age insurance is similarly to be broadened and strengthened. The American report clings to the present method of variable contributions by insured individuals based on wages, with benefits calculated accordingly. This significant difference from the British system is grounded on the great variability in American wage levels and the temper of the people and is probably justifiable in practice if not in theory. The limited lengths of most types of benefit payments do not seem to be as well supported in either respect.

The importance of state and local government bodies in the sphere of social security is recognized, and great efforts are made to define the responsibility of the federal government in relation to these other groups. The gist of the recommendations is to extend the activities of the federal government and to vary federal assistance to the states according to their needs rather than according to their contributions. The unsatisfactory provision of public aid in most southern states makes these changes particularly desirable.

The strength of the American report lies in its excellent summary of historical developments and problems in the field of social security in this country and in its criticisms of existing schemes rather than in its recommendations of a plan for the future. A great many of these recommendations seem sound, but the details of a plan, almost as much as the principles upon which it is based, determine its suitability and control its success. A detailed plan is outside the scope of this report, but it may easily be built upon it. The practical problems to be overcome in evolving a satisfactory American social security system are enormous, but it is to be hoped that this country delays no longer than necessary in working them out. It would not be desirable to copy the Beveridge plan, but its carefully stated principles and assumptions, its evaluation of pros and cons for every proposal, and its attempt to meet and solve difficulties rather than to avoid them should be stimulating to the ultimate designers of an "American Beveridge Plan."

Every American plays a part in the social security system as taxpayer or recipient of public aid or both. It is to his personal interest to be familiar with both present plans and proposed changes, and it is also a public duty. To those for whom it is not feasible to read either or both the reports described here in their entirety, the writer recommends the printed summaries of them which are available.[4]

[4] "After the War—Toward Security," National Resources Planning Board pamphlet, United States Government Printing Office, Washington, D. C., September, 1942, 61 pages, 10 cents.
"The Beveridge Plan," Public Affairs Pamphlets, Public Affairs Committee, Inc., New York, N. Y., 1943, 31 pages, 10 cents.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Development of Radar

U. S. NAVY DEPARTMENT

INTEREST in the remarkable detection and ranging device which has been such an outstanding factor in the war is so widespread that the statement of the U. S. Navy's early development of it, released on May 23, will appeal to all engineers. The text of the statement follows:

In mid-September, 1922, two research scientists, Dr. A. Hoyt Taylor and Mr. Leo C. Young, working in the Naval Aircraft Radio Laboratory, Anacostia, D. C., observed that certain radio signals were reflected from steel buildings and metal objects. They also observed that ships passing by a transmitter and receiver at such frequencies gave a definite interference of pattern. These observations gave rise to the suggestion that:

> "Possibly an arrangement could be worked out whereby destroyers located on a line a number of miles apart could be immediately aware of the passage of an enemy vessel between any two destroyers in the line, irrespective of fog, darkness or smoke screen."

The discovery by Dr. Taylor and Mr. Young, more than 20 years ago, was the birth of radar. Their imaginative, searching preliminary suggestion marked its first possible military application.

As announced in the joint Army-Navy press release of April 25, 1943, the term "Radar" means radio-detecting-and-ranging.

Dr. Taylor and Mr. Young have been connected intimately with the development of radar ever since those fateful days in September, 1922. . . .

Dr. Taylor is now superintendent of the Radio Division of the Naval Research Laboratory. Mr. Young is now assistant superintendent of the same division.

On Sept. 27, 1922, a report on Dr. Taylor and Mr. Young's initial findings and their suggested implications was forwarded to the Bureau of Engineering, Navy Department.

Despite the pressure of their other work and the discouraging factors which face the pursual of most research work, Dr. Taylor and Mr. Young continued their trail. Between 1925 and 1930 the reflection phenomena observed in 1922 was used to measure the height of the Kennelly-Heaviside layer, an atmospheric formation which acts as a reflector for certain beams. Dr. Taylor and Mr. Young did this work in conjunction with Dr. Gregory Breit and Dr. Merle A. Tuve, of the Carnegie Institute. Their associates during this period included Mr. L. A. Gebhard and Mr. M. H. Schrenck.

During this period, Dr. Taylor and Mr. Young also measured the time required for radio signals to go around the world by reflection from the Kennelly-Heaviside layer. For this purpose extremely brief radio signals were employed, and apparatus was designed to both transmit and receive such brief signals. Mr. L. A. Hyland, now with the Bendix Corporation, was one of Dr. Taylor's associates during this early work.

On June 24, 1930, Mr. Hyland, working under Dr. Taylor, observed that aircraft crossing a line between a transmitter and receiver operating directionally gave an interference pattern clearly indicating the presence of such aircraft.

On Nov. 5, 1930, the Director of the Naval Research Laboratory submitted to the Chief of the Bureau of Engineering, Navy Department, a detailed report, prepared by Dr. Taylor, on "radio-echo signals from moving objects." This report summarized all observations made prior to that date, presented the theory underlying the observed phenomena, and concluded with the recommendation that the investigation be continued and intensified.

Dr. Taylor's report having been thoroughly studied, the Radio Division of the Bureau of Engineering on Jan. 19, 1931, assigned the Naval Research Laboratory the following problem:

> "Investigate use of radio to detect the presence of enemy vessels and aircraft. Special emphasis is placed on the confidential nature of this problem."

On Oct. 21, 1931, Captain Harold G. Bowen, U.S.N., then assistant to the Chief of the Bureau of Engineering, (now Rear Admiral, special assistant to the Under Secretary of the Navy), forwarded for comment and consideration to the Naval Research Laboratory certain radio proposals of Lieutenant (now Commander) Joseph N. Wenger, U.S.N. Two weeks later, on Dec. 20, 1931, Dr. Taylor replied that all of Lieutenant Wenger's proposals had already been demonstrated in previous work at the Naval Research Laboratory to have practical possibilities, and again Dr. Taylor recommended that this research be given a high priority.

Meanwhile the theory of reflection from moving objects had been confirmed by experiments conducted in co-operation with the dirigible *Akron*.

At this stage in radar's development the Navy's findings were brought to the attention of the War Department. On Jan. 9, 1932, the Secretary of the Navy wrote the Secretary of War describing the work carried on at the Naval Research Laboratory. This letter contained the following suggestion:

> "Certain phases of the problem appear to be of more concern to the Army than to the Navy. For example, a system of transmitters and associated receivers might be set up about a defense area to test its effectiveness in detecting the passage of hostile aircraft into the area. Such a development might be carried forward more appropriately and expeditiously by the Army than by the Navy."

A copy of Dr. Taylor's report of Nov. 5, 1930, was enclosed with the Secretary's letter, and the War Department was offered the assistance of the Naval Research Laboratory and the Bureau of Engineering in any investigations that Department might desire to make.

By this time airplanes in motion nearly 50 miles from the transmitter had been detected under certain conditions. On July 1, 1932, in one of Dr. Taylor's reports of progress made on the problem assigned Jan. 19, 1931, he described certain tests of aircraft detection at such distances and added that the object of the investigation now was to develop instruments for the collection, automatic recording, and correlating of data to show position, angle, and speed of the approach of objects in the air. The first instruments of this nature were developed by Mr. Robert M. Page, of the Naval Research Laboratory, assisted by Mr. Robert C. Guthrie.

Mr. Page and Mr. Guthrie, since this time, have been constantly engaged in radar research, and many of the radar developments now in use in the Naval service are credited by the Navy Department to the efforts of these scientists.

By March 28, 1933, various types of apparatus and systems for detecting enemy aircraft and vessels had been developed to a degree which enabled the Naval Research Laboratory to outline in detail the theoretical military applications.

In 1935 the Naval Appropriations Committee of the House of Representatives on its own initiative allotted $100,000 for research purposes to the Naval Research Laboratory. This committee has been intensely interested in the development of radar. The committee repeatedly has made inspections at the Naval Research Laboratory and has given special financial support to its work. During most of this period Representatives James E. Scrugham, of Nevada, a former engineer, was chairman of the committee. Mr. Scrugham is now a member of the U. S. Senate.

By this time the Bureau of Standards had been advised of the radar work of the Naval Research Laboratory, and the Bureau of Standards and the Naval Research Laboratory were co-operating with representatives of the Army regarding methods of detecting aircraft by utilizing ultra-high-frequency radio waves. The War Department had emphasized the importance of this project, and constant liaison has been maintained between the Services.

In June, 1936, representatives of the Bureau of Engineering witnessed a demonstration of aircraft detection equipment at the Naval Research Laboratory, and Rear Admiral Bowen, then Chief of the Bureau, directed that plans be made for the installation of a complete set of radar equipment, as then existed, aboard ship.

As a result of studies made during the tactical maneuvers of the U. S. Fleet in the Pacific during the fall of 1936, Admiral A. J. Hepburn, U.S.N., Commander in Chief of the U. S. Fleet (now chairman, General Board, Navy Department), advised Rear Admiral Bowen of the importance of having radar equipment tested with the Fleet.

On February 17, 1937, visiting the Naval Research Laboratory, Assistant Secretary of the Navy Charles Edison (now Governor of the State of New Jersey) and Admiral William D. Leahy, U.S.N., Chief of Naval Operations (now Chief of Staff to the Commander in Chief of the Army and Navy) witnessed a demonstration of the detection of aircraft by the first radar set developed in this country.

The next two years were spent in designing and manufacturing a practical shipboard model. After continual trials, a set of radar, manufactured by the Naval Research Laboratory, was installed on the U.S.S. *New York* late in 1938. During January, February, and March, 1939, this equipment was given exhaustive tests at sea during the winter cruise and the battle maneuvers carried on at that time. The Commanding Officer of the U.S.S. *New York* was most enthusiastic and recommended that the work be continued. Vice Admiral Alfred F. Johnson, U.S.N., commanding the Battleship Division, stated, "The equipment is one of the most important radio developments since the advent of the radio itself."

Decision was made to develop additional radar sets, while, at the same time, it was emphasized that the immediate procurement of this material must not interfere with the progress of the development.

In October, 1939, contracts, on a bid basis, were awarded the Radio Corporation of America for manufacture of six sets of aircraft detection equipment patterned after the original model which had been built at the Naval Research Laboratory and installed in the U.S.S. *New York*.

Two of the major electronics laboratories of the country, Bell and R.C.A., by this time were working in co-operation with the Naval Research Laboratory on radar research and development.

In August, 1940, realizing that this nation was faced with limited radar production facilities in the event of war, Rear Admiral Bowen persuaded Mr. Charles E. Wilson, president of the General Electric Company (now executive vice-chairman of the War Production Board) to institute radar manufacturing at the General Electric plants. Within two weeks Mr. Wilson sent 20 scientists from Schenectady to inspect the Navy's radar equipment at the Research Laboratory. The company's representatives were most enthusiastic.

Two weeks later Mr. Wilson, himself, headed another inspection party and was so impressed that he directed Dr. Walter R. Baker, head of the Radio Division of the General Electric Company, to take the necessary actions to enable General Electric to catch up with the Naval Research Laboratory's radar program. Mr. Wilson additionally reorganized General Electric's Radio Division. Dr. Baker was made vice-president of the General Electric, and General Electric became the first radio company to transfer all of its radio engineers to radar work. Additional radar manufacturing facilities were started immediately. The General Electric Company subsequently was awarded a large contract for radar equipment for naval vessels.

On Oct. 16, 1940, Admiral Bowen appealed to Mr. A. W. Robertson, chairman of the board, and Mr. George Bucher, president of the Westinghouse Electric Company, to participate in the Navy's radar program. Westinghouse representatives visited the Naval Research Laboratory and subsequently immediately reorganized their own radio division and were awarded a large Navy contract for radar manufacture.

In September, 1940, representatives of the British Technical Mission held a series of conferences with representatives of the Navy Department and the Naval Research Laboratory at which time much technical information relating to radar was exchanged. Previously it had been known that Great Britain was in possession of a system for detecting aircraft but most of the details of the British system were unknown here. During this conference with the British Technical Mission, it was found that the British equipment was similar in many respects to the equipment developed by the Naval Research Laboratory, and members of the British Mission stated that the British development had resulted from articles reporting the preliminary work between 1926 and 1930 of Dr. Taylor and Mr. Young, of the Naval Research Laboratory, and Dr. Breit and Dr. Tuve, of the Carnegie Institute, studying the height of the Kennelly-Heaviside layer. With this preliminary study as a base, the British independently had developed their radar system and independently had arrived at frequencies and circuits very similar to those developed in this country.

In October, 1940, Rear Admiral Bowen, then head of the Naval Research Laboratory, was designated co-ordinator of all phases of the Navy's radar program.

By the beginning of 1941, the General Electric, Westinghouse, R.C.A., and Bell Telephone laboratories were carrying on research and undertaking commercial production.

Lieutenant Commander (now Commander) David R. Hull, U.S.N., Assistant to Admiral Bowen, was put in immediate charge of Naval contacts with all private, commercial, and governmental activities engaged in radar research and development, and in this capacity he supervised the development of models which resulted in the first quantity production of many types of radar equipment.

Commander (now Captain) Jennings B. Dow, U.S.N., spent the greater part of 1941 in England obtaining information on British radar methods. Upon his return to the United States, Commander Dow organized the Radar Branch in the Radio Division, Bureau of Ships. Radar procurement and design work in the Bureau of Ships prior to that time had been conducted by Lieutenant Commander (now Commander) Samuel M. Tucker, U.S.N. Major contributions in the radar field also have been made by Lieutenant Commander (now Captain)

M. E. Curts, U.S.N., Lieutenant (now Commander) William S. Parsons, U.S.N., and Lieutenant Commander John F. Mullen, Jr., U.S.N.

Radar research is continuing and new developments are constantly being made by the Government and by private industry. Every manufacturer of any size in the electronics industry is participating. Radar procurement is one of the Navy's prime projects.

Postwar—Two Views

NATIONAL INDUSTRIAL CONFERENCE BOARD

AT the twenty-seventh annual meeting of the National Industrial Conference Board, Waldorf-Astoria Hotel, May 26, 1943, two important addresses on postwar conditions, international and national, were delivered.

The international point of view was discussed by Sir Norman Angell, member of the British Labor Party, and winner of the Nobel Peace Prize in 1933. The forecast of conditions likely to follow the ending of the war was presented by Paul G. Hoffman, president, The Studebaker Corporation, and chairman of the Committee for Economic Development. The addresses follow:

SIR NORMAN ANGELL'S ADDRESS

No one who is old enough, as, alas, I happen to be, to recall the reconstruction efforts made during the last war can forget with what optimism we approached that task of reconstruction and what great expectations we had formed of the outcome. You know, we know, the years of the depression have taught us, of the tragic anticlimax.

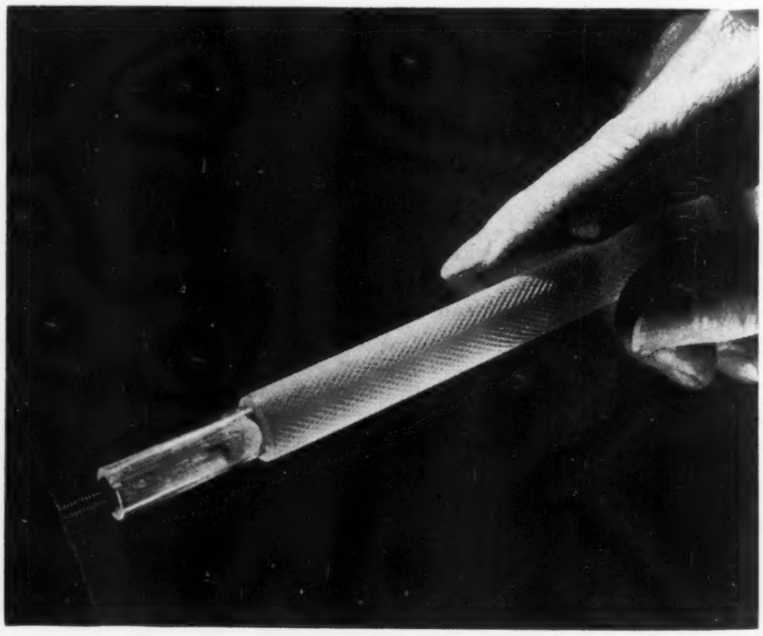
I suggest that if we are to avoid a similar tragedy of reconstruction going to pieces, we have to examine the nature of the mistakes we made, how our failure is explained. Because if we don't, we are quite capable of making the same or similar mistakes again, and failing again.

In the light of that experience I want to suggest that there are two mistakes we then made of which we have to be aware. The first was that we seemed all but completely to overlook the necessary political bases of economic reconstruction. By political bases I mean political order, peace, the absence of violence and war. It is no good having the most beautifully symmetrical plans of reconstruction, whether they are concerned with transportation, petroleum, mining, building, utilities, manufacturing, banking, investment, labor problems, if, just as they are beginning to work, the whole thing is thrown into the melting pot by some new war or indeed by the fear of war and the concentration of all effort upon meeting it. The ink on the last peace treaty was hardly dry before France and Britain began to fall apart in their political co-operation; France began to adopt a policy toward Germany of which British opinion deeply disapproved, although British opinion failed to appreciate the fact that there was one act of Britain which might have changed French policy to Germany. The whole political order in Europe was in a state of fundamental turmoil and chaos; America was washing her hands of the whole business, and there was no agreement between Britain and France, America and France, America and Britain, or between these three states and Russia, or between those four states on the appropriate policy toward Japan. How could any sort of reconstruction have any chance, how could confidence in any economic, monetary, banking, or financial device expect to succeed when we were living on a volcano of that kind?

FOUNDATION OF ECONOMIC RECONSTRUCTION WILL BE POLITICAL

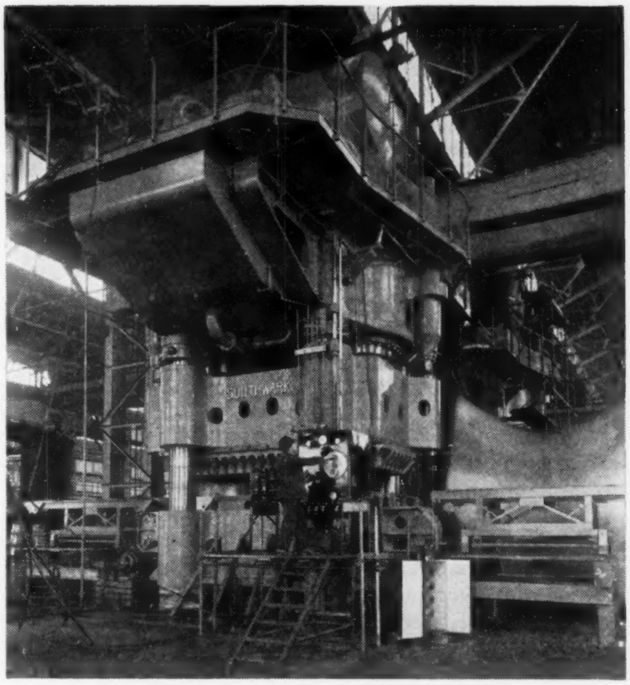
This means that the foundation of any economic reconstruction will be a political foundation. A political foundation means in plain language some dependable arrangement by which aggression, war-making, from any quarter shall be prevented. That of itself, of course, though indispensable, of course, is not enough. Perhaps we don't always distinguish between what is indispensable and what is enough. The foundations are not the house and you cannot live in foundations, but neither can you live in a house built upon rotten foundations. The economic house which we tried to build after the last war had foundations in political quicksands. It never in fact got built because the sands were shifting, and such of it as we did manage to construct came all tumbling about our heads within a couple of decades.

The political principle which must constitute the foundation of economic reconstruction is not after all very complicated, however difficult its practical application may be at times. We must recognize that survival, self-preservation as nations, defense, is the first thing we have to insure. We now know—or ought to know—that that defense must be collective; based on *common* action against aggression, or it cannot exist at all. If we will not hang together for the purpose of resisting aggression, then we shall be hanged separately by any criminal minority that plans to pick us off one by one. It is precisely what has happened to the nations of continental Europe and would have happened to Britain if she had not changed her policy in time and recognized the profound truth, which lies at the basis of all peace, that if we are to defend ourselves we must be prepared on occasion to defend others. She decided in March, 1939, to undertake the defense of Poland. If she had adopted that principle twenty years earlier in the case of France, eight years earlier in the case of China, five years earlier



NEW PLASTIC WRENCH

(A new-type wrench made of light-weight Plexiglas and designed for assembly operations on radio equipment used by the U. S. Navy Bureau of Ships has been developed by Wells-Gardner Co., Chicago, and the Klise Manufacturing Co., Grand Rapids, Mich. The new Plexiglas wrenches are used for tightening hexagonal nuts in aligning intermediate frequency coils in Naval radio sets. A material of high dielectric strength, ready machinability, and toughness is necessary for this job. It is resistant to weathering and aging and it may be machined, drilled, and threaded like any soft metal.)



MASSIVE 5500-TON CAPACITY SOUTHWARK HYDRAULIC PRESS

(One of three just completed by the Baldwin Southwark Division of The Baldwin Locomotive Works especially for forming duralumin aircraft parts. The press is of the rapid-action type and is completely automatic, having control of pressure, operating speed, and length of stroke. It also is equipped for semi-automatic or manual operation. Press platens are single steel casting and weigh approximately 160,000 pounds each. Electric motors, with a total of 400 hp, are required to operate the pumps located on the platform, 30 ft long, 23 ft wide, which supports the complete power unit, control gear, and operating valves. The press stands 33 feet high and weighs approximately 950,000 pounds.)

in the case of Ethiopia, there would have been no second world war.

This time we must make the political foundations sufficiently secure so that our elaborate planning will not, just as it is getting under way, be all blown to pieces by some criminal five per cent of the world that hopes to dominate the very divided and quarreling ninety-five per cent.

That, it seems to me, is the one lesson we have not yet perhaps sufficiently faced. It is the prerequisite for the success of the plans you have been elaborating. But there is another.

ECONOMIC ILLITERACY A "STUMBLING" BLOCK

The final sanction for these plans of yours will be either legislative or a general acceptance by the people. The public, in other words, will in any case have the last word. But that public was revealed after the last war—let us be frank and honest about it—as cursed by quite incredible economic illiteracy. I have in mind such examples as the behavior of the British and French publics about reparations.

More than one historian has declared that no single factor was more responsible for the financial and monetary disintegration after the last war than what one economist has called the "running sore" of reparation during twelve years; the uncertainty which because of that unsettled question hung over all monetary and financial settlement and arrangement. If only Britain and France had made up their minds to do in 1920, say, what they did twelve years later at Lausanne, much of the economic blizzard might have been avoided, possibly runaway inflation in Germany might have been escaped; in any case the problem would have been much easier, and if the inflation over central Europe had been avoided, we might never have heard of Adolph Hitler.

Why did the public take twelve years to make a decision which could have been made in one, or, for that matter, in twelve weeks?

I remember arguing this matter with some members of Parliament who later were my own colleagues when I sat in the House. They were demanding that Germany should pay astronomical sums and they attached a condition: Germany was not to increase her exports. They wanted money, not goods, no German competition in trade. I wanted to know what they meant by money. If we had been able to take, not merely the monetary gold in Germany, but every pair of earrings, we could only have collected about one per cent of what we were claiming. I asked my colleagues to assume that we had taken all the gold. How would they then propose to collect money while prohibiting any increase in German exports?

One of them, a very popular and influential figure, nevertheless insisted that, if the Government had sufficient intestinal fortitude, it could collect the money. He had a plan. He would go to Berlin with a regiment or two and notify the German Government that unless certain trucks he had ready were loaded up with the money they owed us within two weeks, twenty per cent of the German cabinet would be executed. If then the money was not available, another twenty per cent would be executed. It would, he said, secure the money.

I asked him to imagine that his plan had succeeded and that he had brought this money to London and Paris. What would he do with it there? The butcher and baker would not take German marks. Nor would the income-tax collector. That money had value in one place in the world only, in Germany, where truly it could be exchanged for goods. But my friends had imposed a condition. Those goods must not leave Germany—German exports were not to be permitted. What, therefore, I asked, would the plan amount to? Having collected this money and brought it to London, they would have to select favored portions of the population and have them migrate to Germany and go on drinking beer until the reparations were exhausted.

Is that difficult to see? It took our people twelve years to see it. I don't think the French ever saw it. And possibly certain senators and newspaper proprietors have taken secret oaths that in respect of the British debts they never shall see it.

If the historians are right and the bungling on reparations did play a large part in producing the financial disorders of Europe, a sufficiently large part to account in some degree for the rise of Hitler, then the future historian will have to relate that European civilization nearly wrung its neck, owing to failure of the public to understand a point which could be made clear to any intelligent adolescent in half an hour.

Is not this something of a reflection upon an education that is presumed to prepare us for democracy, for giving into the hands of millions the final word on these policies, economic, financial, monetary, which we have been discussing?

I have selected out from a round dozen of fallacies which prevailed at the time of the last peace-making one of them, a political fallacy, the assumption that each could defend himself and let others go hang. That assumption has put twenty nations in Europe today under the heel of Hitler. I frankly doubt whether even today the average voter in most countries would accept the proposition that if we will not defend others, it is physically impossible effectively to defend ourselves. Yet, if that proposition is not accepted, a third world war is inevitable.

I doubt very much, taking the example of economic illiteracy I have selected, whether the mass of voters are prepared to accept the proposition that, if we will not buy the goods and services of others, it is an economic impossibility for those others to buy our goods and services. Both propositions are mere truisms, undeniable. They should be self-evident. But even today in our democracies, political and economic illiteracy is such that both propositions are widely, angrily, passionately

denied. While this remains true, no stable reconstruction is possible.

This is not necessarily an expression of pessimism. The very simplicity of the points which we have missed is ground for hope that, with no great revolutionary change, much better can be done than has been done. Let us at least determine that much better shall be done.

MR. HOFFMAN'S ADDRESS

It is my studied opinion that shortly after peace comes America will have to attain peacetime production and employment levels which, three years ago, would have seemed fantastic. Failure to do so would put free society in jeopardy.

HIGH LEVEL OF EMPLOYMENT MUST BE ATTAINED QUICKLY

A high level of employment must be attained quickly after peace comes, because too much unemployment for too long is a direct invitation to dictatorship. Today there is general agreement on that point. Perhaps what has not been so clearly recognized is the further point that, if government provides too many jobs for too long, the result will be exactly the same, so far as the effect on the maintenance of free society is concerned. Pressures created by either too much employment, or by too much government employment, may vary somewhat but lead to the same result. Too much unemployment, too much government employment for too long, either or both spell death to a free society!

While we must keep constantly in mind the need for jobs, high-level employment by itself is not enough. High-level employment alone could be attained very easily if, in striving for that goal, we disregarded completely the reasons for its attainment—a high standard of living and the maintenance of our free society. To avoid hazards in the attainment of those objectives we must accept as our primary objective high-level production in private industry. Let us never forget that there just is no substitute for work.

In my approach to this problem of postwar employment in private industry you will note I use the term high-level employment and not *full* employment. Full employment is a nice-sounding phrase, but exactly what does it mean? Does it mean a job for every man and woman, for every husband and wife in America? If so, what kind of a job? Does it mean a job working 40 hours a week, with sufficient pay to provide a satisfactory standard of living or a job working 12 hours a week with just enough pay to provide a bare existence? Does it mean a job created by giving up steam shovels and going back to hand shovels or, for that matter, teaspoons? Without the answer to those questions, the term full employment is utterly meaningless and misleading.

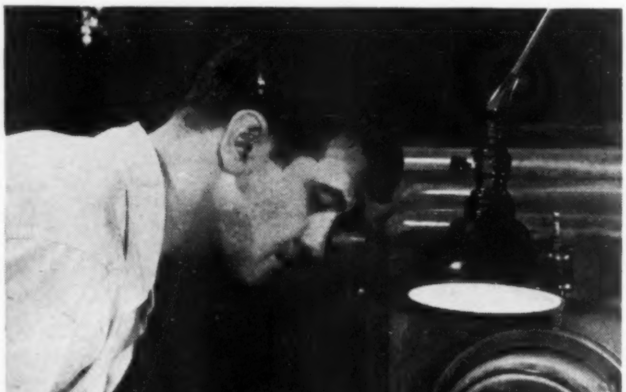
The question of creating jobs as a result of technological advancement deserves special emphasis. Despite seeming acceptance of the premise that jobs are created by selling goods for less, in times of stress we are apt to forget it. If there are any questions in your mind in that regard they should be answered by the little-publicized recent report of the National Bureau of Economic Research entitled "Employment in Manufacturing, 1899–1939—An Analysis of Its Relation to the Volume of Production." In this report the Bureau points out that the industries with particularly large increases in both employment and output between 1899 and 1939 were in general those in which exceptionally large declines occurred in employment per unit of product. It mentions the automobile industry as having cut jobs per unit most sharply in that period and yet registering the largest gains both in total numbers employed and in output. In contrast the lumber industry increased its employment per unit of product and suffered a sharp reduction both in total employment and total output. In the light of this report it should be clear to you why we decided to make high-level production our primary objective.

You may say that the term high-level employment is just as meaningless as full employment. Perhaps it is, until its meaning is spelled out. That is what I propose to do. When the Committee for Economic Development was organized we realized that if we hoped to make any contribution to the solution of the postwar employment problem, our first job was to get the facts. Facts are illusive and lack glamor, but I have never forgotten what President Wilbur of Stanford said many years ago: "If you don't get the facts, the facts will get you." Now, I propose to give you the facts. I propose to tell you exactly what we believe will constitute high-level employment after the war.

In order to develop the facts we went back to 1940, our last peacetime year. We did that because we realized that there is no relation whatsoever between our present war economy and a peacetime economy. Taking employment first, we found that approximately forty-six million people were gainfully employed in the United States in 1940. Less than six hundred thousand of them were either serving in the armed forces or working in armament production. From an employment standpoint, the situation in 1940 was not satisfactory because it is estimated that there were from six to nine million competent workers unemployed.

In contrast to 1940, it is estimated that by the end of this year more than sixty-two million people will be employed in our working-fighting force, and of this number no less than twenty millions will be directly engaged in the manufacture of war goods. If we had to provide employment for all of these people after the war the task would be staggering, but that is not likely.

Assuming that several million women, along with overage and underage men, will return to their homes after the fighting stops, leading economists estimate that we will have to provide regularly something like fifty-eight million jobs, with a normal work week, to have a *satisfactory* level of employment. Approximately two million of these will be in the armed forces, so that industry and government presumably will have to provide some fifty-six million jobs.



A DIFFICULT AND PRECISE JOB IN THE MANUFACTURE OF CUTTING TOOLS

(Form relieving of the cutting edges, or tapering of the teeth so that they bite in with each revolution. The tool being made is a milling cutter, one of thousands now being turned out at a Ternstedt plant of the Fisher Body Division of General Motors.)

Jobs stem from the output of goods and services. The economists estimate that to provide fifty-six million jobs our output of goods and services in the postwar period would have to total between 135 and 145 billion dollars a year. This estimate is made in terms of the 1940 dollar. Please note I speak of gross output and not national income. You can appreciate the enormity of that job when I tell you that in 1940, when our gross output of goods and services exceeded that for any previous single year, it totaled less than 100 billion dollars. Under the pressure of war our output this year is expected to approximate 155 billion dollars but, as I mentioned before, there is no relation whatsoever between a wartime and a peacetime economy.

HOW CAN HIGH-LEVEL PRODUCTION BE ATTAINED?

How can private industry achieve the high-level production necessary to make its maximum contribution to the attainment of what we consider a satisfactory level of employment?

I should like to answer that question by telling you that in the consideration of this problem the men associated with me in the Committee for Economic Development have come to two main conclusions:

1 Individual enterprises must start *now* to plan their own postwar products and postwar markets;

2 The environment in the postwar period must be favorable to the expansion of enterprise.

Now I should like to tell you how the C.E.D. proposes to make its contribution. First, let me mention that I have no confidence whatever in the ability of any agency—public or private—to make over-all plans for our economic system, or for our business program. However, I do have the highest confidence in the ability of individual businessmen to plan for the future of their own businesses. In my opinion the initiative and resourcefulness of the individual enterprisers in this country constitute one of our greatest national resources. The problem is properly to develop this great resource, to stimulate hard thinking on the part of these entrepreneurs.

The job of stimulating, encouraging, and helping these individual enterprisers make their own postwar plans is the responsibility of our Field Development Division. This division is headed by a committee of twelve regional chairmen, one for each of the federal reserve districts. These regional chairmen are appointing district chairmen who are responsible for the organization of local or community committees. These local committees are completely autonomous. Their job is to mobilize the brains in their communities so that the communities, themselves, can solve their own postwar problems. The only thing we ask them to do is to pass on to the national organization any ideas they may develop so that we may make them available to other community committees.

We are not overly concerned about planning by the very large employers, some five hundred of the three million business establishments in this country. They have the resources and the technical ability to do a first-class job of their own. It is the smaller businesses—the approximately two million actual employers and the one million self-employers—which need both encouragement and help in getting their programs under way. In the aggregate these work-givers provide many millions of jobs. They are the grass roots from which our economy grows. They are the shock troops we must use to win our objectives. They must start planning *now*, and they must plan *boldly*, and they must plan *intelligently*.

But the soundest of individual planning will come a cropper unless the economic environment—the business climate in the postwar world—is favorable to expansion of enterprise.

RESEARCH DIVISION OF COMMITTEE FOR ECONOMIC DEVELOPMENT

The Conference Board, the National Bureau of Economic Research, and the universities have contributed significantly to the economic thinking of our country for many years. The Conference Board has done excellent work over the past twenty-seven years. However, there is such a tremendous need for an improved climate that our committee felt all available economic brainpower, not now utilized, should be mobilized and concentrated on a study of the policies of government, business, and labor, that have an important bearing upon production and employment. Our group firmly believes that all policies which interfere in any way with expanding production and, therefore, with employment, must be changed. They took the position that the approach to these studies must be completely objective and solely in the public interest. They finally came to the conclusion that we could make our greatest contribution to the problem by setting up an entirely new temporary research organization to carry forward studies with the sole objective of suggesting changes which would help to maintain a free and dynamic society. The policies to be studied are being selected by a research committee of businessmen, with the advice of a distinguished group of economists and social scientists headed by Dr. Slichter of Harvard. The projects themselves are the responsibility of our research staff headed by Dr. Yntema of the University of Chicago.

The research group will go into a lot of complex questions. Incentives for venture capital will be studied—and the impact of taxation on those incentives. They may suggest how best war contracts may be terminated to bring about fair settlements *quickly*, so that contractors can get their money in a few months and turn it into productive channels promptly. They may have recommendations about the disposal of war plants, about what to do with surplus stocks at the end of the war . . . and about many other problems, the answers to which may easily set the pattern of our economy for the rest of this century.

The economists will publish their conclusions without revision or censorship from the businessmen on the committee. The latter will retain only one prerogative—the right to dissent.

I am certain that much good will come as a result of bringing together these additional professors from their ivory towers and the businessmen from their counting houses in this area of productive social action. The only objective, remember, is to examine those policies which affect production and, therefore, job creation, and, where necessary, to recommend changes in the interest of the general public welfare.

Any policies of business which are opposed to the general public welfare should give way—as should any policies of government or labor. If we are going to win the peace after *this* war, businessmen will have to be Americans first and businessmen second; labor leaders, Americans first and labor leaders second. That also goes for the farmers and the government administrators.

BASIC "CLIMATE" REQUIREMENTS

I am looking forward to studying carefully the findings of this able research group. Beliefs that I now hold quite firmly may be modified by these studies—some of which should be available to all of us sometime next fall. Nevertheless, I am strongly inclined to believe that a few conditions must characterize any economy in which free enterprise is to remain the structural base. Among these are:

1 There must be a restoration of rewards for risk-taking on the part of business and industry. Our tax laws must be so revised as to stimulate vigorously the entrance of venture-capital into productive enterprise—where jobs can and will be created.

2 Some solution must be found for the special problems of small businesses. It has been too tough for small businesses to be born of late—and even tougher for them to stay alive. Small business is the bedrock of the free enterprise system.

3 Both business and government must make every effort to see that competition is put back into the competitive system—to the fullest extent possible. Competition is a stimulant for the enterpriser. Without it his initiative and resourcefulness cannot be brought into full play.

Our Committee is concerned directly only with the domestic economy. But the international economic climate which prevails after the war will have an important bearing on employment in private industry in America. Because of the great strides being made in the field of aeronautics, all natural boundaries are disappearing rapidly. America of the postwar period will hold an entirely different position in this world of ours than the America of the '30s. By the time this war ends every country in the world will be our close neighbor. In the light of this geographical revolution, does not isolationism become a thing of the past? Are not those of us who persist in thinking as isolationists headed down a blind alley?

IT CAN BE DONE

Given a favorable economic climate, given the courage to plan boldly, and given the will to do the job, we have every chance of meeting the challenge of postwar production and employment successfully—because the market is going to be there in a big way.

Certainly the desire for goods will be in the people's hearts. The money to buy will be in their hands. As the war ends, the nation will be experiencing a boom in terms of national income—and a depression in terms of what civilians have been able to buy with the income. People will want new things; many of them will *need* new things; and almost all of them will have more savings than they ever had before in their lives.

Even in the field of capital goods, vast immediate expenditures for reconverting production back to peacetime output will be necessary in many plants, where armament machinery will become as useless as did peacetime tools when war began. "Most of the normal replacement, as well as the desired increases in capacity, will necessarily be postponed until after the war," says the Department of Commerce's new study, 'Markets After the War,' "and that is accentuated by a forced liquidation of business inventories beginning in the last half of 1942."

Moreover, in this short war period we have compacted as much technological development as might ordinarily have taken place in a couple of decades.

All of these factors will combine to help us get jobs to the idle millions *before* long unemployment brings them fear, and disillusionment, and want.

Attacking this task of insuring high-level production and employment gives us as businessmen an inspiring chance, by *bold* action based on *bold* planning, to help build a better new world. Certainly none of us wants to go back to the prewar world of the '20s or the '30s.

Portable Gas Producers

ENGINEERING

ACUTE shortage of gasoline in Great Britain and on the continent has led to the development and use of gas producers for automobiles, particularly trucks and busses.

German portable gas-producer practice is reviewed in an article appearing in the May 28, 1943, issue of *Engineering*. According to this article, nearly ten years of serious effort in Germany to develop the use of gas producers for traction purposes have clarified the general problems, which are now considered to fall under four heads: (1) Producers must be designed to suit fuels which are likely to be obtainable in reasonable quantities at all times; (2) reliability, together with the utmost simplicity of servicing and maintenance; (3) gas cleaning, of a very high order of efficiency; and (4) high performance.

The obvious fuels are wood, peat, anthracite, and low-temperature coke from bituminous coal. Germany also has two other fuels, brown-coal semicoke and peat coke, of which the former is available in very large quantities. Even brown-coal briquettes are now being considered as a suitable fuel for portable producers, except possibly for marine work, since their high ash and tar content would make it necessary to use elaborate de-ashing and tar-separating equipment for which there would not be room on a motor vehicle.

All these fuels fall into two groups; those which yield more or less tar, as wood, peat, and brown-coal briquettes, and those with a low tar yield, as true anthracite, coke, and semicokes.

Wood is the fuel that has been used in Germany above all others. However, the wood situation in Germany is now such that more serious attention has been paid to anthracite and other mineral fuels; and, at least in principle, all conversions of commercial vehicles since July 1, 1942, have been to burn coal or coke instead of wood.

Some of the foremost German internal-combustion engine makers have engaged in the manufacture of producers which are designed to suit the makers' engines. For the larger particles of dust, cyclones are used almost without exception in German portable compressors, while filters of glass- and wood-wool, wet separators, oil-bath filters, and the like, are used for removal of the finer dust particles. Tar separators are not much used, since tarry fuels are usually gasified in downdraft producers which make so little tar that a simple cooler is sufficient to yield a clean gas after the dust content has been efficiently removed. The accompanying table gives a list of the producers approved by the Generatorstab up to late in 1941.

GERMAN PORTABLE GAS PRODUCERS

——	Type.	Air Supply.	Other Characteristics.	Preheater.	Coarse Cleaner.	Fine Cleaner.	Cooler.	Tar Separator.	Starting Method.
Wood Producers.									
Imbert	Up-draught	Five tuyères	Heavily-waisted grate of heat-resisting steel. Gas off-take through double casing.	None	Settling chamber with impact plates.	Cork	Tubular, in front of radiator.	None	Fan.
Klöckner-Humboldt-Deutz.	Up-draught	Central tuyère	Waisted brick-lined casing. Double casing in lower half.	None	Cyclone	Powder	Tubular, in front of radiator.	None	Diesel operation switching over to gas (Zündstrahl).
Ostmark (Gustloff)	Up-draught	Numerous tuyères	Gas off-take at bottom	None	Cyclone	Wood-wool or glass-wool.	Box-cooler	None	Auxiliary tuyère and fan.
Zeuch	Up-draught	Numerous tuyères	Gas off-take at bottom	None	Settling chamber with impact plates.	Glass-wool	Box-cooler	None	Fan.
Wisco	Up-draught	Six tuyères	Square section refractory grate.	None	Cyclone		Tubular, beneath chassis.	None	Fan.
Südgas (Rau)	Up-draught	Tuyères	Refractory grate. Gas off-take at bottom.	None	Cyclone	Wood-wool	Box-cooler	Metal gauze	—
RKTL	Up-draught	Five tuyères	Waisted grate made of refractory material. Well insulated.	Air preheater (300 deg. C.)	Cyclone	Glass-wool	Tubular	None	"Hansa" method (2 cylinders on petrol).
Anthracite Producers.									
Klöckner-Humboldt-Deutz.	Up-draught	Grate	Lined fuel-pot	Annular jacket	Cyclone	Wet cleaner	None	Impact plates	Fan.
Wisco	Up-draught	Grate	Square section, lower part with water-jacket. Central gas off-take.	Preheating in water-jacket	Cyclone	Delbag oil filter	Tubular	Impact plates	Fan.
Hansa	Up-draught	Grate	Square section, lower part with water-jacket. Central gas off-take.	None	Settling chamber.	Oil-bath, filter followed by cork filter.	None	None	Fan.
Daimler-Benz	Cross-draught (Gohin).	Water-cooled tuyère.	Dry blast	None	None	Cloth filter preceded by active carbon.	None	None	Petrol.
Henschel-Finkbeiner.	Tuyère, but upward gasification.	Water-cooled tuyère (and grate).	Dry blast through tuyère; wet blast through grate.	None	Cyclone	Powder	Tubular	None	Fan.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Euler's Number

TO THE EDITOR:

The writer has been following the interesting discussion carried on by Professor Moody and Professor Thomas[1] on the dimensionless number to serve as a criterion for cavitation and offers comment on the choice of the dimensionless parameter for cavitation testing under actual conditions.

Experiments by Numachi[2] have shown that the condition generally assumed necessary for the inception of cavitation, namely, the lowering of the pressure in a liquid to the vapor pressure of that liquid, is an inaccurate criterion for cavitation in water under actual operating conditions. In all cases where cavitation occurs, the water usually contains a large amount of, or is nearly saturated with, dissolved gases or air, causing cavitation to begin at pressures which are not as low as those given by calculations using the saturated-vapor pressure. The problem of choosing a criterion for the beginning of cavitation thereby becomes more difficult as it must provide for the effect of air content.

Using small glass tubes with venturi-type constrictions, Numachi performed experiments with fresh, salt, and sea waters with varying air contents and established the importance of air content upon the pressure at which cavitation begins. This has been corroborated by years of experience in attempting to scale up results of cavitation tests on models of ship propellers to the scale of the prototype.

It was suggested that instead of the criterion, $\left(\frac{p_0 - e}{q_0}\right)$ which is generally used, there should be substituted in place of the vapor pressure, e, a value p_k, the critical pressure at which cavitation begins, to be determined experimentally.

The problem is complicated by the fact that the value of p_k is not only dependent to a great extent upon air content, but also upon the shape of the pressure-distribution curve, which determines the length of time that a particle of water remains in a low-pressure region. This time factor becomes important in dealing with water containing a large amount of air, because of the time necessary for air to be drawn out of solution at the surfaces of separation.

The writer believes that, in determining the value of p_k, in $\left(\frac{p_0 - p_k}{q_0}\right)$, there should be included the effect of the number of undissolved solids in the water upon the inception of cavitation. These undissolved solids, the quantity of which is indicated by the turbidity of the medium, serve as "nuclei" for the formation of cavities and play an important role in determining the pressure at which cavitation begins. Tests have shown that varying the amount of undissolved solids in a cavitating region has an effect upon the incipient point that is similar to the effect of changes in air content.

This consideration points to the inaccuracy of the use of a vibratory-type apparatus as the means of determining the critical pressure, as recent tests performed by Dr. Rightmire, at M.I.T., showed that cavitation re-forms with ease at a spot where it has just collapsed, "indicating that some sort of nuclei are present which do not exist in a noncavitating fluid." This method of determining pressures at which cavitation begins might lead to erroneous results, since the repeated formation and collapse of the bubbles probably serve to concentrate these nuclei.

ALFRED M. FEILER.[3]

TO THE EDITOR:

In regard to the discussion,[1] on Euler's number, it should be remembered that calling a dimensionless group Euler's number might lead to a confusion with Euler's constant, 0.5772 +.

Euler's constant appears in the summation of the series $1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} \ldots\ldots + \frac{1}{n} = \log_e n$ + Euler's constant + x, where x is a small term which gradually vanishes as n increases.

Thus the sum of $1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} \ldots + \frac{1}{n}$ when n = 1,000,000,000 = 21.3006 approx. When n is infinite, the sum is, of course, infinite. However, if every term containing the digit 5 is omitted from this infinite series, the sum is only 22.5 approx.

A. H. PUGH.[4]

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[1] "Euler's Number," Letters to the Editor, by H. A. Thomas, MECHANICAL ENGINEERING, March, 1943, pp. 210–211; and by Lewis F. Moody and H. A. Thomas, May, 1943, p. 372.

[2] "Über die Kavitationsentstehung mit besonderem Bezug auf den Luftgehalt des Wassers," by F. Numachi, Technology Reports of the Tohoku Imperial University, vol. 12, 1937, no. 3, p. 84.

[3] Research Engineer, Taylor Model Basin, U. S. Navy.

[4] Colonel, U.S.A., O.R. Aux., Associate A.S.M.E.

Engineering Education

TO THE EDITOR:

The article[5] by R. G. Freeman in the March issue typifies, as he says, a form of pressure which is constantly being put on engineering educators, to which they offer a defense which is far too infrequently supported by practicing engineers.

Basically, this article poses the question of whether engineering is a profession or a trade. If it is accepted that it is desirable to provide the type of training which the author proposes, then it is distinctly not a profession, but a trade. The training of technicians is the province of trade schools, not of engineering colleges, and the type of work outlined is distinctly that of technicians, not necessarily of engineers. The author points out very clearly that engineering training is not at all necessary for this kind of work, which places a far greater premium upon ingenuity and resourcefulness than it does upon mathematics.

In the writer's opinion, all good engineering must relate basically to mathematics, or the vague distinction between engineering and technique disappears altogether. By this it is not meant to disparage the value of ingenuity and resourcefulness, since in the field of engineering which the writer has followed, i.e., that of automatic control, the practice has been far ahead of the development of the theory, and virtually all of the development has been attributable to these two qualities. Certainly no really great piece of engineering is produced without their employment to a great extent. But without the check of mathematics, these qualities give rise to many mistakes, and the author emphasizes that, in the field he discusses, practically all progress has been made by cut-and-try methods, which means a plenitude of mistakes.

The writer's experience, and that of most other engineers who encounter a wide variety of problems, leads to the earnest recommendation to engineering educators that they emphasize more strongly the basic studies of hydraulics, mechanics, thermodynamics, and physics, in addition to pure mathematics, rather than devote as much time as has become customary to specialized studies. Perhaps this will be possible only when the specialized phases have become graduate studies, as are medicine and law, but until that time, engineering will have difficulty in justi-

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[5] "The Maginot Line of Engineering Education," by R. G. Freeman, MECHANICAL ENGINEERING, March, 1943, pp. 202–204.

fying its claim to being a profession. It seems to me that this claim can be justified only if the necessary training is given to men who already have acquired an education, and this is not the case at present. Certainly, every concession in the direction which the author desires postpones the day when this claim can be made with full justification.

J. B. McMahon.[6]

To the Editor:

The analysis of the problems posed by Mr. Freeman and the difficulty of their solution agree very closely with my own. Also I have been surprised in finding that "productive-tooling engineers" whom I have met have no idea of any fundamental principles or methods of attack or procedure to be used in teaching their subject. We tried to give something like this and secured a very good man (highly recommended by his company). The course consisted of two evenings a week, but he found it impossible to accomplish anything. All he could do was to explain what he had done, but he did not have the ability to explain why he had done anything. His teaching was barren of results.

We have been giving a course in time study but it had not occurred to me that this might be an ideal training for productive-tooling work. We have, however, made some approach to this problem by having the students time an operation on an engine lathe and then the same operation on a turret lathe and other similar problems. I think this has some real value as it requires definite analysis of the reasons for differences in time required.

Mr. Freeman suggests that students time operations performed by a proficient workman. I have an idea that college time study could be just as well done by studying times used by students as time used by proficient workmen. We do have a shop course for freshmen, and we have been assigning a number of these men to a senior to be trained and timed by him. We find that there is a standard time for a freshman to perform a shop operation. It is much longer than the time required by a proficient workman and is not in a handbook, but year after year the time remains fairly constant. The point is that the student learns that he can analyze what he has available instead of talking about what he might do if he had a competent workman.

I agree with Mr. Freeman's statements regarding the value of shopwork for students in the main but I know of no way by which a student can get any conception of the difficulty of obtaining 0.001 in. comparable with trying to turn a shaft to 0.764 in. without spoiling it. After he has done this he always has a picture of what it means when he writes a dimension on a drawing or specifies a tolerance and he has much more respect for a machinist who can produce accurate work.

I hope Mr. Freeman will comment on the idea of timing students who are doing shopwork. This of course *includes the problem of working up standard procedures*.

George L. Sullivan.[7]

To the Editor:

Personally, I am of the opinion that the undergraduate curriculum in engineering should be less specialized, rather than more specialized. However, the emphasis in such specialization as we give must be shifted from the old-fashioned type to the current needs of industry.

A. A. Potter.[8]

To the Editor:

Some of the comments on my paper indicate that some readers have misunderstood some details of it and have missed the main thesis in principle.

However, the excerpt from Dean Potter's letter expresses my position regarding specialization in engineering *education*.

Education, understood to be a formal preparation of the individual for social effectiveness, cannot take the entire lifetime of the individual in getting him ready. Sometime he must make his contribution. To make the contribution effective, education must provide him with all the pertinent background acquired by those who have gone before with a usefully high degree of certainty of his benefiting by their experience. Thus *education* for the living individual must be an effective short cut to that experience. And to be effective, those methods of record and prediction known as "scientific" are our soundest resource.

One reader says he believes "that all good engineering must relate basically to mathematics. . . . . . ."

He has the relation reversed: Mathematics is the tool and its use must be related to engineering processes. By its use, record of past performance is taken to predict to usefully close limits the future performance—the *probable* future performance—of an engineering project. This is in fact the functional definition of science, a sort of time tool, as I am sure Samuel Butler would say, which permits us in the present to refer to the past to foretell the future.

This same reader wants basic studies in the classic divisions of science. Of course I agree. Are not large resources in the literature of that science available? Are not sound texts on the shelf with beautiful mathematical laws stated therein, and to their hypothetical problems solutions quite unequivocal in the textbooks for that "basic" course? Then what becomes of the young hydraulics "engineer?" Are there no courses in applied hydraulics? Or, for the thermodynamics student, no applied studies in power-plant engineering? Of course there are.

Then if these fields of engineering have basic courses followed by applied courses, what is wrong with establishing a basic course of record and formulation, as I submit time study must become, to be followed by applied courses in the enormously expanding field of productive-tooling design?

Here it may be pertinent briefly to point out a significant fact. Engineers are beginning to become aware that time is the common basic factor of human accomplishment. As a common factor, it is coming to be used as a measure of human accomplishment. Economic worth of an engineering accomplishment is measured by the number of man-hours put into the accomplishment, and balanced by the saving of man-hours which the accomplishment itself provides throughout its useful life. This is a fundamental concept, especially true of engineering projects, a house, a bridge, an automobile, a productive-tooling setup.

We can attach a trading symbol to our time and measure in terms of money; but the symbolization becomes attenuated and eventually crawls off into steel vaults and holes in mountains. Still, we continue to trade our man-hours for other man-hours just the same.

For the productive-tooling setup, the man-hours charged against it are weighed against alternative setups with different man-hours charged for their construction and setup. And their *prospective* producing rate is predicted to determine the one which will produce a unit workpiece with the lowest over-all man-hours' charge. At no point need money enter the problem. If it does, it merely starts an argument; for money is a trading element; man-hours, from the time the material is dug out of the ground until polished to the last shadow, is the real common denominator. This point may need amplification for some, which for the lack of space cannot be given here.

Time study, carried to a logical achievement, becomes a basic course in the study of the industrial enterprise.

[6] Republic Flow Meters Co., Chicago, Ill. Mem. A.S.M.E.

[7] Dean, College of Engineering, University of Santa Clara, Santa Clara, Calif. Fellow A.S.M.E.

[8] Dean of Engineering, Purdue University, Lafayette, Ind. Past-President A.S.M.E.

Where the flow of workpieces step by step to the end of the line is the veritable lifeblood of the enterprise, the time rate of flow and the time charges to be made against the productive tooling setups by which the flow is accomplished, are crucial. In ordinary engineering design, force analysis, as considered by the elementary textbooks, is crucial. In living concepts, such as production flow, time analysis is crucial to success; and the more coherent thinkers on the productive process consider it so. Time study therefore if used comprehensively, can be expected to emerge as no mere study in a technique which, in fact, is fast becoming standardized, but as a basic study of industrial economy in its most vital aspects.

Mr. McMahon states that the article "points out very clearly that engineering training is not at all necessary for this kind of work. . . . . ." i.e., productive tooling. On the contrary, the article takes up a great deal of space pointing out the industrial turmoil resulting from lack of *educated* engineers, those who can think logically and constructively rather than relying on "ingenuity and resourcefulness," as he puts it.

Taken as a whole the comment of Mr. McMahon seems to have missed the point which the article advances, namely, that room not only should but can be made for productive-tooling engineering in colleges; that it should be established in the curriculum on a sound scientific basis; that it may well be so established in university schools more or less inaccessible to industry by a sound and comprehensive application of time study to the understanding of the relationship of productive-tooling engineering to productive-tooling accomplishment. In addition, theoretical mechanics, strength of materials, and hydraulics, among others, are prerequisites; also training in the technique of mathematics, or "pure" mathematics. The industrial productive process is coming of age; the educators would do well not merely to describe and to draw pictures of it, but also to account for how it gets that way.

Another reader says: "I am particularly interested in knowing whether or not you use full-time instructors or the part-time services of industrial engineers to give the training."

Generally, but not necessarily, full-time teachers of top quality will tend to teach engineering values; part-time engineers of top quality, as far as they have teaching effectiveness at all, do best as instructors for training values.

Regarding Dean Sullivan's use of student laboratory work as subjects for time study, I would say that this is a good trial step forward for senior instruction in mechanical processing. But he must be sure a definite correlation is established between reduced time charges and improved productive-tooling engineering setups.

Regarding the value of machine-shop training and how the "student can get a conception of the difficulty of obtaining 0.001 in., etc.," I would say, only, so far so good. You have shown him the difficulty; now show him the several engineering solutions to the difficulty. Not only must the student have "more respect for a machinist who can produce accurate work," he must also have respect for a tooling setup by which the same tolerances may be maintained on a whole string of workpieces by almost any workman; and the student must know and respect the fundamental engineering reasons why freehand machining and productive machining differ.

Regarding working up standard procedures, time standards, and tool costs in terms of time to make the tools and setups are emphatically the subject matter for productive-tooling engineers. Especially is this true when comparative analyses of alternative methods for realizing the same geometry on a workpiece are studied for engineering differences, so that the student is confronted with a choice of selection, not with an inspirational imperative. One difference between an educated man and a trained man is that the first recognizes alternative choices to make an intelligent selection; the second sees few or no alternatives.

Education may be considered to take to three levels depending on how far instruction is removed from the actual experience. First there is the detailed practice itself, guided, controlled, limited to an extremely minute portion of the useful activities of society. Then there is the symbolization and rationalization of practice at mathematical and statistical levels. This is the level of scientific approach. The third level is generalization, which is the level of philosophy attempting to integrate total recorded knowledge. If any one of these levels provides the key it has never been pointed out; for throughout the land are found educational programs of every variety. One may be sure, however, that their intrinsic evaluation depends in each case on the proportions of the level of instruction and the effectiveness as well as the comprehensiveness of the short cuts to appurtenant experience. And I for one advocate the middle level for personal contribution and practical accomplishment in engineering, and especially for the productive-tooling field.

R. G. FREEMAN.[9]

[9] General Motors Institute, Flint, Mich., Member A.S.M.E.

Misquoted

TO THE EDITOR:

Your letter to me communicates complaints that in my review of the Leith Furness-Lewis book[10] I misquoted Mr. Herbert Feis, adviser on international economic affairs in the Department of State.

In my review I referred to Mr. Feis as "as quoted in the newspapers." The full text of his address on April 19, 1943, having been communicated to me I am instantly moved to agree that Mr. Feis was misquoted by the press and that he merely referred to the entertainment of certain views without saying, or suggesting, that he entertained them.

With this apology to Mr. Feis let me add that I had no intention of bringing out anything more than the variety of views that are held in respect of the fourth article of the Atlantic Charter. One of those views is that in respect of raw materials there should be an international pool of them. Another view is that the victors should control raw materials by an international policing body for the enforcement of peace. As to the latter proposal, Dr. Leith in accepting an honorary degree from the Graduate School of Stevens Institute of Technology, June 3, 1943, came out more strongly in favor of it and reluctantly as he says, than he did in his book. Without cataloguing all of the views as to postwar policy the ultimate is laissez faire, or let nature take its course with the minimum of assistance.

W. R. INGALLS.[11]

President's Page

TO THE EDITOR:

Reading the "President's Page" in the March issue of MECHANICAL ENGINEERING was a real pleasure. I think many members of the Society will welcome an opportunity to discuss the broader problems of engineering. Certainly the engineer is now extending his influence much beyond that of technology. He needs more and more to lead in respect to the social aspects of the application of technology to our problems of production. It is my opinion that a movement in this direction in the editorial policies of MECHANICAL ENGINEERING and in the program activities of the Society will do much to increase interest in A.S.M.E.

H. G. THUESEN.[12]

[10] "World Minerals and World Peace," a review, MECHANICAL ENGINEERING, June 1943, pp. 447–448.

[11] Consulting Engineer, New York, N. Y.

[12] Head, Dept. of Industrial Engineering, Oklahoma Agricultural and Mechanical College, Stillwater, Okla. Mem. A.S.M.E.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Air-Conditioning Analysis

AIR-CONDITIONING ANALYSIS. By William Goodman. The Macmillan Company, New York, N. Y., 1943. Cloth, $6^{1}/_{8} \times 9^{1}/_{4}$ in., 455 pp., 32 tables, 108 illus., 7 folding charts, $6.

REVIEWED BY N. C. EBAUGH[1]

THE primary purpose of this book is to present a comprehensive treatment of the fundamental psychrometric principles which form the basis of air conditioning. The author has produced a treatise of outstanding and lasting value and has succeeded in stating in a clear and concise manner the scientific and mathematical principles governing air and water-vapor mixtures.

The graphical solution of air-conditioning problems is stressed throughout the book and the analyses of numerous air-conditioning processes are profusely illustrated with skeleton psychrometric charts. The author presents his own charts based on the specific humidity and enthalpy co-ordinates of Mollier. The advantages of using these co-ordinates as compared with the more commonly used co-ordinates of specific humidity versus dry-bulb temperature are given with the aid of numerous illustrations to practical problems.

A special feature of the book is the section on psychrometic tables and charts which occupies 164 pages of the text. The tables gives values of specific humidity, volume, humid specific heat, and enthalpy from—40 F to 200 F and for barometric pressures from 22 to 32 inches of mercury. A table of specific humidity for air pressures up to 100 lb per sq in. abs is one of several special tables included.

The chapter sequence is arranged in logical order, starting with the necessary fundamental concepts of psychrometry and continuing with the construction and use of the psychrometric chart. Following these are several chapters devoted to the solution of problems involving the supply of air under various required conditions.

One of the most valuable features of the book is the presentation of the "Water-Air" chart. The co-ordinates of this chart are temperature and enthalpy and it is particularly useful for obtaining graphical solutions to problems involving the exchange of heat between air and water. Many practical problems in connection with air washers, cooling coils, and evaporative condensers require the exchange of heat between air and water and these are used as illustrative examples.

No effort is made to give the description of air-conditioning apparatus and no illustrations of such apparatus are used at any place in the book. The usual subjects such as fans, duct work, sound control, and air cleaning which are found in most air-conditioning textbooks are completely omitted. The title might be more descriptive of the contents if it were "Psychrometric Calculations of Air Conditioning."

Due to the limited scope of the subject matter, this work would not be well suited for the usual first course in heating and ventilating or air conditioning as given to undergraduate students in the engineering colleges. On the other hand, every serious student of air conditioning who is engaged in research, design, development, or application would do well to include this book in his technical library.

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The Theory and Practice of Heat Engines

THE THEORY AND PRACTICE OF HEAT ENGINES. By D. A. Wrangham. The University Press, Cambridge, England; The Macmillan Company, New York, N. Y., 1942. Cloth, $6^{1}/_{2} \times 9^{3}/_{4}$ in., 768 pages, 380 figures, 13 plates in colors, $10.50.

REVIEWED BY J. C. SMALLWOOD[2]

THIS work is almost encyclopedic, covering thoroughly and in detail not only fundamental thermodynamics but allied topics as fluid flow, heat transmission, combustion, air conditioning, and, on the descriptive side, the usual heat engines and auxiliaries and apparatus for testing them, such as CO_2 recorders, calorimeters, etc., and even including test procedure.

The author very commendably gives a short treatment on the kinetic theory of gases as an approach to the thermodynamics of perfect gases and vapors. Under perfect gases are included the Carnot, Otto, Diesel, and other ideal cycles with air as medium. These topics are supplemented by excellent though condensed chapters on the internal-combustion engine, gas, gasoline, and oil, in the latter half of the book. Also illustrating perfect gas laws is a chapter on air compression and compressors containing not only theory but descriptive matter in admirable form. The thermodynamics of vapors follows and after that a chapter on entropy; then, in order, air-steam mixtures, reciprocating steam engines, refrigeration, fluid flow, heat transmission, steam condensers, steam turbines, etc.

The advantage, if any, of this arrangement of subject matter is not clear; for example, to treat steam turbines much later than reciprocating engines, boilers after internal-combustion engines, internal-combustion engines as a subdivision of gas cycles and also toward the end of the book in separate chapters. Parenthetically, the divisions on internal-combustion engines might have included considerably more on the gas turbine, which is now receiving so much attention. Chapter 3 on partial pressures and gas mixtures might have been advantageously combined with chapter 8 on mixtures of air and steam. In this connection it is noted the old equations for specific heats of gases are used instead of the latest from spectroscopic data. The chapter on entropy follows those on the thermodynamics of gases and vapors. It seems preferable to introduce the conception of entropy early in the study of the properties of heat media. The treatment of reversibility is very meager even for a much less pretentious work on heat engines. This important subject should have received more attention.

The theory of the steam turbine is presented in a lucid manner and in general conforms to modern practice. Due to differences in practice, American engineers may take exception to some of the statements made but these are of secondary importance. More might have been added to the chapter dealing with modern developments in turbine plants and condensers.

From the American viewpoint it is unfortunate that the Centigrade pound system of thermal units is employed in

[2] Associate Professor of Mechanical Engineering, The Johns Hopkins University, Baltimore, Md.

place of the British thermal unit. This will restrict its extensive use as an American textbook that its worth otherwise merits. It is unfortunate, too, that nomenclature and symbols do not conform with modern American good usage in some important particulars. For example, the term "latent heat," the much objected-to term "total heat," and "sensible heat" are used throughout. Confusing abbreviations are sprinkled through the text, instead of symbols; for example *I.E.* instead of our *u* for internal energy.

Another defect of the book is the failure to apply generally the steady flow energy equation which has been found such a useful approach in American pedagogy. Instead, the chapter on fluid flow contains an exposition of Bernoulli's theorem including the items of internal energy, heat and work, which, of course, is equivalent to the steady-flow equation, but full advantage is not taken by applying the theorem generally to engineering processes.

In dealing with combustion, analyses are developed on the basis of weights in pounds or volumes in cubic feet, and as an alternative method, calculations based on the mol are explained. There seems no reason for presenting both, as the mol basis is better, and sufficient, and is now extensively used in American colleges.

An outstanding feature of merit throughout the book is its illustrations. They are exceptionally well drawn and clear; confusing details are omitted, and both charts and diagrams are easily visualized. Photographic reproductions, so often vague blurs in technical books, are exceptionally clear and good. A unique addition has been made to many of the diagrams, namely, colors which markedly add to their impressiveness and interpretation.

Many numerical examples are worked out in the text, which, as in all such books, add distinctly to its value. These are supplemented by many problems, with answers, for the reader to solve.

Without doubt, this book will be considered by the discriminating reader as a valuable contribution to the literature on heat engines.

Books Received in Library

AIRCRAFT PRODUCTION, Planning and Control. By H. D. MacKinnon, Jr. Pitman Publishing Corp., New York, N. Y., and Chicago, Ill., 1943. Cloth, $6 \times 9\frac{1}{2}$ in., 253 pp., diagrams, illus., charts, tables, \$3.75. This manual is intended to assist in training those intended for positions in the production departments of aircraft factories. The relation of the production department to other departments is described and the work of each outlined. The work of the various divisions of the production department is described, and the methods used to control and co-ordinate their work explained.

AMERICAN SOCIETY FOR TESTING MATERIALS, 1942 BOOK of A.S.T.M. STANDARDS, including Tentative Standards (a Triennial Publication). 3 volumes. Part I, METALS, 1643 pp.; Part II, NONMETALLIC MATERIALS, Constructional, 1482 pp.; Part III, NONMETALLIC MATERIALS, General, 1637 pp. Published by American Society for Testing Materials, Philadelphia, Pa., 1943. Cloth, $6 \times 9\frac{1}{2}$ in., illus., diagrams, charts, tables, \$27. (3 parts); \$9 each part. Also three unbound sets of Emergency Alternate Provisions. This edition, the first in three years, contains the standards, adopted and tentative, as of the present date. Emergency standards and alternate provisions issued to expedite procurement or conservation of materials are also included.

APPLIED MATHEMATICS FOR TECHNICAL STUDENTS. (Rochester Technical Series.) By M. S. Corrington. Harper & Brothers, New York, N. Y., and London, England, 1943. Cloth, $5\frac{1}{2} \times 9$ in., 226 pp., diagrams, tables, \$2.20, without tables; \$2.80, with tables; \$0.75, tables alone. Arithmetic, algebra, logarithms, and trigonometry are all included in this small volume, which is intended for trade schools, factory courses, or pre-engineering study and is also suitable for home study. Emphasis is on the practical applications.

APPLIED MECHANICS. (Rochester Technical Series.) By R. M. Biehler. Harper & Bros., New York, N. Y., and London, England, 1943. Cloth, $6 \times 9\frac{1}{2}$ in., 291 pp., diagrams, charts, tables, \$3.25. A textbook adapted for brief courses and intended for students having limited mathematics, in which practical applications are emphasized.

CALCULUS MADE EASY. By S. P. Thompson. Second edition, enlarged. Macmillan Co., New York, N. Y., 1914 (reprinted 1943). Cloth, $4\frac{1}{2} \times 7$ in., 301 pp., diagrams, charts, tables, \$2. This little textbook, offered as "a very simplest introduction to those beautiful methods of reckoning which are generally called by the terrifying names of the differential calculus and the integral calculus" first appeared, anonymously, in 1910. In 1914, an enlarged edition appeared under the author's name, which is now reprinted. In vigorous, colloquial style it presents the fundamentals of the calculus.

CAMERON HYDRAULIC DATA, edited by G. V. Shaw and A. W. Loomis. Eleventh edition Ingersoll-Rand Co., Cameron Pump Division, New York, N. Y., 1942. Fabrikoid, $4\frac{1}{2} \times 7\frac{1}{2}$ in., 233 pp., diagrams, charts, tables, \$3. This handbook presents in convenient form a collection of data, largely in tabular form, frequently wanted in dealing with practical problems involving the handling of steam, water, and other liquids.

A COURSE IN POWDER METALLURGY. By W. J. Baëza. Reinhold Publishing Corporation, New York, N. Y., 1943. Cloth, $6 \times 9\frac{1}{2}$ in., 212 pp., illus., diagrams, charts, tables, \$3.50. The aim is to provide a course in the subject for students of metallurgy. The history and modern development of the field are summarized briefly. The production of powders, powder specifications, the classification of particle size, cohesion, manufacturing problems, and machines are discussed. A course of instruction is presented, with information on laboratory equipment and cost, and directions for a series of experiments. The course is based on actual experience.

DICTIONARY OF SCIENCE AND TECHNOLOGY IN ENGLISH—FRENCH—GERMAN—SPANISH. By M. Newmark. Philosophical Library, New York, N. Y., 1943. Cloth, $6 \times 9\frac{1}{2}$ in., 386 pp., tables, \$6. This dictionary contains a list of some 10,000 English scientific and technical terms, with their equivalents in French, German, and Spanish. French, German, and Spanish indexes make it possible to use any of these languages with English. The selection is a good one and includes many recent terms which are absent from older books.

DIESEL AVIATION ENGINES. By P. H. Wilkinson. National Aeronautics Council, New York, N. Y., 1942. Cloth, $5\frac{1}{2} \times 8\frac{1}{2}$ in., 92 pp., diagrams, charts, tables, \$1. The development of this engine and its principles are outlined briefly. The Guiberson and Junkers engines are described in some detail, flights with Diesel-powered aircraft recorded, and advantages of the engine for aviation indicated.

DIESEL AND GAS ENGINE POWER PLANTS. By G. C. Boyer. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, $6 \times 9\frac{1}{2}$ in., 447 pp., illus., diagrams, charts, tables, \$4. A practical discussion of internal-combustion power plants, intended for designers and operators. The book is not confined to a discussion of engines, but treats the plant as an entity, and attention is given to the economic conditions, power-plant design, buildings, fuel, piping, maintenance, electric equipment, and similar subjects.

ELEMENTS OF AEROFOIL AND AIRSCREW THEORY. By H. Glauert. University Press, Cambridge, England; Macmillan Co., New York, N. Y. 1943. Cloth, $5\frac{1}{2} \times 9$ in., 228 pp., diagrams, charts, tables, \$3.50. The theory of the aerofoil and the airscrew is presented here in a form suitable for students with no previous knowledge of hydrodynamics, and with a minimum use of complex mathematical analysis. The author first reviews the necessary portions of hydrodynamic theory. Following this, the lift of an aerofoil in two-dimensional motion, the effect of viscosity and its bearing on aerofoil theory are presented, followed by the development of the theory of aerofoils of finite span. The final chapters develop the theory of the airscrew.

ELEMENTS OF TECHNICAL AERONAUTICS. National Aeronautics Council, New York, N. Y., 1942. Cloth, $5\frac{1}{2} \times 8\frac{1}{2}$ in., 214 pp., illus., diagrams, charts, tables, \$2. The theory of flight, aerodynamics, airplane design, the autogiro, the helicopter, and associated questions are discussed briefly by various experts. The fundamentals are explained without mathematics.

ENGLISH FOR ENGINEERS. By S. A. Harbarger, A. B. Whitmer, and R. Price. Fourth edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, $5\frac{1}{2} \times 8\frac{1}{2}$ in., 225 pp., \$1.75. This well-known guide to the study of English for engineers emphasizes the point of view of previous editions. The aim is to guide the student in his study of English and to point out the ways in which he can apply the basic principles of writing to his own activities. Part one of the book provides material for an inventory of the skills used in writing and speaking. Part two illustrates the use of these principles in the writing of letters, reports, professional papers, etc. The new edition has been skillfully revised and greatly improved.

ESSENTIALS OF DRAFTING. By C. L. Svenens. Third edition. D. Van Nostrand Co., New York, N. Y., 1943. Cloth, 7×10 in., 295 pp., illus., diagrams, charts, tables, \$2.35. The basic principles of drafting and their applications are covered in this text, without unnecessary ramifications. The result is a direct treatment suited to the needs of those who make drawings and those who are to read them. The new edition has been entirely rewritten and reset in a larger format.

FLIGHT INSTRUMENTS. By H. W. Hurt and C. A. Wolf. National Aeronautics Council, New York, N. Y., 1942. Cloth, $5^1/_2 \times 9$ in., 92 pp., illus., diagrams, charts, tables, \$1. This book describes the instruments in use today and shows their purposes.

FLYING BOATS. By H. C. Richardson, W. E. Beall, and C. W. Manly. National Aeronautics Council, New York, N. Y., 1942. Cloth, $5^1/_2 \times 8^1/_2$ in., 122 pp., illus., \$1. This book is a popular account of the development, handling, and testing of flying boats. Handling when in the air and when afloat, launching and beaching, and shipboard catapults are described and illustrated.

FUNDAMENTALS OF STRESS ANALYSIS, Volume 1. By A. Deyarmond and A. Arslan, prepared and edited by Associated Aeronautical Staff of Aero Publishers, Glendale, Calif., 1942. Cloth, $6 \times 9^1/_2$ in., 256 pp., diagrams, charts, tables, \$3. The purpose of this book, the first of a two-volume textbook, is to describe fundamental methods of analyzing the stresses in the types of structures that are used in airplanes. The subject is presented in a simple, practical manner.

GUN CARE AND REPAIR, a Manual of Gunsmithing. By C. E. Chapel. Coward-McCann Inc., New York, N. Y., 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 454 pp., illus., diagrams, tables, \$3.75. This admirable book covers in precise detail the art of gunsmithing, from the layout and equipment of the shop to the methods of decorating guns. The needs of the home gun craftsman are especially considered, and the book provides all that the amateur needs to know in order to make, repair, and alter rifles and other firearms. The Garand rifle, the Thompson submachine gun, and the Army automatic pistol are described in detail.

HIGH-SPEED DIESEL ENGINES for Automotive, Aeronautical, Marine, Railroad, and Industrial Use, with a chapter on Other Types of Oil Engines. By P. M. Heldt. Fourth edition. P. M. Heldt, Nyack, New York, N. Y., 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 430 pp., illus., diagrams, charts, tables, \$4. During the seven years that have elapsed since the last revision, Diesel practice has undergone many changes. These changes have been incorporated in the present edition, which contains considerable new material. New chapters on lubrication and on supercharging have been added, with new material on fuels, injection pumps, governors, cooling injection, nozzles, and on two-stroke engines.

INDUSTRIAL ELECTRICITY AND WIRING. By J. A. Moyer and J. F. Wostrel. Third edition. McGraw-Hill Book Co., New York, N. Y., and London, England, 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 541 pp., illus., diagrams, charts, tables, \$2.75. The underlying principles of electricity are outlined, and the proper methods of wiring for light and power are presented fully and clearly, for use by students and electricians. The present edition has been based on the 1940 National Electrical Code. It has also been enlarged by chapters on fluorescent lighting and the prevention of radio interference.

MATERIALS HANDLING, Principles, Equipment and Methods. By H. E. Stocker. Prentice-Hall, Inc., New York, N. Y., 1943. Cloth, $6 \times 9^1/_2$ in., 309 pp., illus., diagrams, charts, tables, \$5 (\$3.75, school edition). The fundamental principles involved in the economical handling of those materials not handled in bulk, and the equipment and methods used, are described and explained in this text. A large amount of information about trucks, tractors, conveyers, cranes, and other equipment is provided, with many illustrations.

MATHEMATICS DICTIONARY, compiled from the literature and edited by G. James, assisted by R. C. James. Revised edition. The Digest Press, Van Nuys, Calif., 1943. Fabrikoid, $6 \times 9^1/_2$ in., 273 pp. + 46 pp. tables, diagrams, charts, \$3. This dictionary covers the vocabulary of mathematics from arithmetic through integral calculus. Both popular and technical definitions are frequently given, or else the definition is adapted to the mathematical maturity of the probable user. The needs of secondary schools and laymen have received special attention. The new edition has been enlarged and revised.

PHYSICS AND PHILOSOPHY. By J. Jeans. The Macmillan Co., New York, N. Y., The University Press, Cambridge, England, 1943. Cloth, $5^1/_2 \times 9$ in., 222 pp., diagrams, \$2.75. The revolution in physics which has taken place in recent years has not only changed our views of that science. It has also affected the scientific basis of philosophy and thereby our general view of the world we live in. In this interesting volume, the author traces the progress of philosophic thought through the ages and of physics since the time of Newton and shows how modern theories of physics affect our thinking on religion, on free will, and on the nature of man.

SHIP EFFICIENCY AND ECONOMY. By G. S. Baker. "The Journal of Commerce and Shipping Telegraph," Charles Birchall & Sons, Ltd., Liverpool, England, 1942. Fabrikoid, 7×10 in., 145 pp., Index, pp. I–IX, diagrams, charts, tables, 42s. In this work the Superintendent of the William Froude Laboratory discusses the question, "What is it that makes a satisfactory and seaworthy ship?" On the basis of actual ship data and those obtained with ship models, he considers such matters as roughness of surface and fouling, wind resistance and hull shape, rough water, rolling, pitching, steering, steering and stability of course in shoal water, working conditions of propellers, economical speed and margins of power. The treatment is nonmathematical.

SHOP MATHEMATICS AND SHOP THEORY. By J. M. Amiss, G. K. Shurtleff, and H. G. Moltzau. Harper & Brothers, New York, N. Y., and London, England, 1943. Cloth, $5^1/_2 \times 8$ in., 360 pp., illus., diagrams, charts, tables, \$1.60. The authors of this work are connected with the educational department of the Chrysler Corporation, and this book is based on long experience in teaching shop men. The course covers mathematics as used in the shop, including logarithms, mensuration, geometry, and trigonometry. It also covers such topics as safety and fire protection, gages, cutting tools and their heat-treatment, gearing, machine tools, superfinish, and oilite bearings.

STREAM FLOW, Measurements, Records and Their Uses. By N. C. Grover and A. W. Harrington. John Wiley & Sons, New York, N. Y., Chapman & Hall, London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 363 pp., illus., diagrams, charts, tables, \$4. The collection, computation, publication and subsequent use of records of stream flow are discussed in this volume, whose authors have had long experience in this field. The reasons why records of the quantity and quality of the discharge of surface streams and of ground water are needed as a basis for their development are explained. The selection of sites for gaging stations and the equipment and operation of such stations are described, together with the computing and publishing of the results.

TEXTBOOK OF OFFICE MANAGEMENT. By W. H. Leffingwell and E. M. Robinson. S cond edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 469 pp., diagrams, charts, tables, \$3. The principles of scientific manager ment are presented in clear language, and theiapplication to office organization is discussed in detail and illustrated by numerous examples and practical problems. All phases of office work and equipment are considered. The book is an excellent text.

S.A.E. HANDBOOK, 1943 edition. Society of Automotive Engineers, New York, N. Y., 1943. Fabrikoid, $5^1/_2 \times 8^1/_2$ in., 810 pp., illus., diagrams, charts, tables, \$5. The new edition follows closely the model of the earlier ones, but the standards have been brought up to date, and the other data carefully revised.

SECONDARY RECOVERY OF OIL IN THE UNITED STATES, sponsored by various committees of the American Petroleum Institute, New York, N. Y., 1942. Fabrikoid, 8×11 in., 259 pp., illus., diagrams, charts, maps, tables, \$3.50. This volume contains a collection of papers upon the recovery of petroleum by injecting air and gas into underground reservoirs or by flooding them with water. The papers contain the best information available at present on the economics of the methods, on the porosity, permeability, thickness, and area of oil-producing reservoirs, and on the amounts of oil recovered and recoverable by these methods. Each paper is by an author with practical experience in the field of which he writes.

SUB-ATOMIC PHYSICS. By H. Dingle. Ronald Press Co., New York, N. Y., 1943. Cloth, 5×8 in., 272 pp., illus., diagrams, charts, maps, tables, \$2.25. As used here, sub-atomic physics includes those divisions of physics (light, electricity, and magnetism) in which the structure of the atom is fundamental. This text, with the companion volume on mechanical physics, presents a course in which physical principles are presented in a manner that enables their application to aeronautical and related studies to be readily understood. The book is intended especially for students preparing for the air services.

TECHNIQUE OF PRODUCTION PROCESSES. By J. R. Connelly. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 430 pp., illus., diagrams, charts, tables, \$4. The aim of this book is to give the student a knowledge of the elementary principles of industrial operations which will provide a background for advanced specialized work. Attention is concentrated on the operations of casting, forming, material removal, and joining, which are described and illustrated. Auxiliary services, such as material handling, stores, plant services, standardization and gaging, methods and job study, are explained. A final chapter discusses the economics of new equipment.

VECTOR AND TENSOR ANALYSIS. By H. V. Craig. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England. 1943. Cloth, 6×9 in., 434 pp., diagrams, tables, \$3.50. This text is intended primarily for those who use vector and tensor analysis as a tool. For them it provides a fairly rigorous course which does not call for a thorough knowledge of modern advanced calculus, but only for acquaintance with the standard first course in the subject. The book opens with a section that supplies the necessary mathematical background. This is followed by a section on elementary vector analysis and one on tensors and extensors. The final section considers some applications to classical dynamics and to relativity.

WAVES AND WAVE ACTION, A Bibliography of Books, Periodicals, and Society Publications appearing from 1687 through February, 1943. Compiled by C. C. Lee, Vicksburg, Miss., May, 1942, typewritten, paper, $8 \times 10^1/_2$ in., \$5. This bibliography lists over 800 references to papers dealing with waves and wave action which appeared during the years 1687 to 1942, inclusive. The entries are arranged by authors and are, in most cases, briefly abstracted or annotated. Subject and chronological indexes are provided.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Papers on Aviation Attract 1200 at 1943 A.S.M.E. Semi-Annual Meeting at Los Angeles, June 14–17

DOMINATED by a strong aviation flavor in its technical sessions and held in the West Coast center of the aviation industry, the 1943 Semi-Annual Meeting of The American Society of Mechanical Engineers proved to be one of the most successful in the history of the Society. A total of more than 1200 members and guests registered for the four-day session held at the Biltmore Hotel in Los Angeles, California, on June 14 to 17.

The Oil and Gas Power and Applied Mechanics Divisions were scheduled to hold separate national meetings elsewhere and were not included in the Los Angeles sessions. Following its regular procedure, meetings of the A.S.M.E. Council and its Executive Committee, as well as the semi-annual business meeting of the Society, were also held. Officers elected for the 1943 administrative year have already been announced in the July issue of MECHANICAL ENGINEERING.

Technical Sessions

The technical meetings opened Monday noon, June 14, with a panel discussion of post-war aviation entitled "Conversion From Combat to Commerce." This was led by such outstanding speakers as Arthur Nutt, vice-president of the Wright Aeronautical Corporation, J. Parker Van Zandt, technical consultant to the Civil Aeronautics Board, Washington, D. C., and Gordon D. Brown, director of market research and planning, Douglas Aircraft Company. Their discussions included words of caution in speculating on the future of commercial aviation, the possibilities in the development of South American air-transport activities, and the need for special consideration in design of both aviation equipment and manufactured products where shipping by air is to be a significant factor.

On Monday evening, under the leadership of Prof. T. A. Watson, a carefully organized panel on the subject "Design for Production" attracted an audience of more than 400 engineers. Eight engineers of well-known aircraft-manufacturing concerns made up the panel and discussed a prepared list of topics. Questions from the floor amplified the comments of panel members.

Following this general session technical meetings were held on: Production Engineering, Management, Women in Industry (both in vocational and engineering activities), Applied Mechanics, Heat Transfer, Railroads, Hydraulics, Rubber and Plastics, and Petroleum.

The pioneering work of the aviation industry in training women for essential jobs, both in shopwork and in engineering, was the subject of two half-day sessions in which many interesting and thought-provoking ideas were brought forth. Particular emphasis was given to the fact that industry must employ women on these jobs if it is to maintain its war-production schedules, and the essential problem is one of finding the best methods whereby they may be adequately trained.

One of the most interesting and best attended of the technical sessions was the joint meeting of the Aviation and Applied Mechanics Divisions held on Tuesday, June 15. An overflow audience of between three and four hundred aeronautical engineers heard papers by three of the outstanding authorities in aircraft structures and participated in a lively discussion following their presentation. The speakers included Prof. Stephen Timoshenko of Stanford University, Dr. Th. Von Kármán, California Institute of Technology, and Eugene Lundquist, of the National Advisory Committee for Aeronautics.

A.S.M.E. Calendar

of Coming Meetings

September 30–October 2, 1943
Joint meeting of the A.S.M.E. with The Engineering Institute of Canada
Toronto, Ontario, Canada

October 28–29, 1943
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Pittsburgh, Pa.

November 29–December 3, 1943
A.S.M.E. Annual Meeting
New York, N. Y.

April 3–5, 1944
A.S.M.E. Spring Meeting
Birmingham, Ala.

June 19–22, 1944
A.S.M.E. Semi-Annual Meeting
Pittsburgh, Pa.

(For coming meetings of other organizations see page 34 of the advertising section of this issue)

Luncheon and Dinner Meetings

A number of interesting talks were presented at the several luncheon and dinner meetings scheduled throughout the session. These included a most interesting discussion by Warren H. McBryde, past-president of the Society, concerning his experiences in Washington in connection with special war-production assignments. The Tuesday dinner meeting was addressed by Mr. Mac Short, vice-president in charge of engineering, Vega

GROUP VISITS PLANT OF KAISER COMPANY, INC., DURING A.S.M.E. SEMI-ANNUAL MEETING IN LOS ANGELES

Aircraft Corporation, on the subject "Aviation and the War." While at the Wednesday luncheon members and guests had the privilege of hearing General E. T. Sorensen of the Army Air Force Staff Intelligence speak on the subject, "Application of Air Power."

The banquet, which marked the high point of the meeting, was held Wednesday evening, at which time Harold V. Coes, President of the Society, presented his paper on "Education for Management." This has already appeared in the July issue of MECHANICAL ENGINEERING.

The program was completed by Col. James L. Walsh, chairman of the A.S.M.E. War Production Committee, who gave one of his characteristically inspiring and illuminating talks on the importance of production planning in the war effort. Colonel Walsh's talk was entitled "The Clock Will Conquer."

The closing luncheon meeting on Thursday was addressed by Harold Adams, chief of the mechanical and equipment section, Douglas Aircraft Company, on "Tolerance and Dimensional Control and Its Effect on Airplane Production."

Plant Trips

Members and guests had the opportunity of visiting some of California's most important industries. Through the courtesy of the Kaiser Company, Inc., the steel plant at Fontana was visited. Three aircraft companies arranged inspection trips, Consolidated-Vultee Aircraft Corporation, Vega Aircraft Corporation, Burbank, Calif., and Douglas Aircraft Company, Santa Monica, Calif. In addition there were trips to the Twentieth Century Fox Film Studies and the California Shipyards at Wilmington, Calif.

Patents Exhibition

An interesting and valuable exhibit, made available through the co-operation of the Alien Property Custodian, included a collection of over 35,000 mechanical patents issued to inventors of enemy nations.

Credit for Success of Meeting to Local Committees

The splendid success of the 1943 meeting is due in no small measure to the fine work of the local committees who devoted much effort to the development of the program in spite of the heavy demands on their time under present emergency conditions. The meeting as a whole was under the direction of J. Calvin Brown, general chairman.

The Reception Committee was headed by Paul L. Armstrong, chairman, and a group of 30 active members whose contributions cannot be credited in detail.

Registration was under the direction of Bernhardt N. Palm, while the Women's Committee consisted of Mrs. Edward Timbs, chairman, and Mrs. B. R. Coupland.

Numerous inspection trips to aircraft and shipbuilding plants and motion-picture studios were made available to members through the fine work of the committee headed by J. Calvin Brown.

The success of the technical sessions was due to the outstanding work of the Technical Affairs Committee headed by E. M. Wagner, as chairman, and including Paul L. Armstrong, J. Calvin Brown, and Ray G. Roshong. Much credit in this connection must also be given to Prof. John E. Younger, secretary of the Aviation Division, for the extensive planning and groundwork which he did on this program in the early spring of 1943.

M. J. THOMPSON.[1]

[1] Professor of Aeronautical Engineering and chairman of the Department, University of Texas, Austin, Texas. Mem. A.S.M.E.

A.S.M.E. Applied Mechanics Division Holds Successful Meeting

Over a Hundred Register at Carnegie Institute of Technology June 25–26

THE Applied Mechanics Division of The American Society of Mechanical Engineers held its tenth National Meeting at the Carnegie Institute of Technology, Pittsburgh, Pa., June 25 and 26. The total number registering was 109.

Sessions on plasticity, elasticity, and photoelasticity were held on Friday, June 25, and a session which included papers on diverse subjects on Saturday, June 26. In the absence of Prof. L. H. Donnell, Illinois Institute of Technology, Commander W. P. Roop, U.S.N., presided over the first session. M. Hetényi, Westinghouse Electric and Manufacturing Company, presided over the second session, and L. M. Tichvinsky, U. S. Naval Experiment Station, over the third.

Prof. W. R. Work Gives Welcome Address

The technical sessions took place in the Little Theater Building of the Institute and were opened by an address of welcome given by Prof. W. R. Work of the College of Engineering. All papers were well received and although, due to late receipt of manuscripts, preprints of all papers were not available at the meeting, considerable discussion took place on all papers presented.

The Division Dinner held in Webster Hall was attended by 87. After the dinner a very interesting and instructive talk was given by Dr. Robert F. Mehl, director of the Metals Research Laboratories, Carnegie Institute of Technology, on the "Electron Microscope." The talk was illustrated by lantern slides showing how this instrument is being applied to, and the necessary technique developed for, research on the structure of metals and their alloys. At the close of the Saturday session a demonstration was made of the microscope by Dr. C. S. Barrett and his assistants which served to implement the importance of this new instrument in the field of metals and other research.

The success of the Applied Mechanics Meeting was due in large part to the hospitality offered by the Carnegie Institute of Technology and also to the efforts of the local Committee, which consisted of Prof. M. M. Frocht, Carnegie Institute of Technology (chairman); Prof. T. G. Estep, Carnegie Institute of Technology; Dr. A. Nadai, Westinghouse Electric and Manufacturing Company, and Mr. R. E. Peterson, Westinghouse Electric and Manufacturing Company.

JOHN M. LESSELLS.[2]

War Shipping Administration Needs Men With Sea Experience

ACCORDING to the War Shipping Administration, by the end of 1943 new ships flying the flag of the United States will require 120,000 men this year. The greatest need is for men with sea experience of certain skills, i.e., mates, engineers, able seamen, cooks, bakers, and qualified members of the engine department.

Although few members of the A.S.M.E. will qualify for the particular jobs needed to be filled, attention to this need is made at the request of the War Shipping Administration in the hope that word can be passed along to men able to fill these positions.

Qualified men should communicate with the local office of the Recruitment and Manning Organization, of the War Shipping Administration, the local office of the United States Employment Service, or the War Shipping Administration, Washington, D. C.

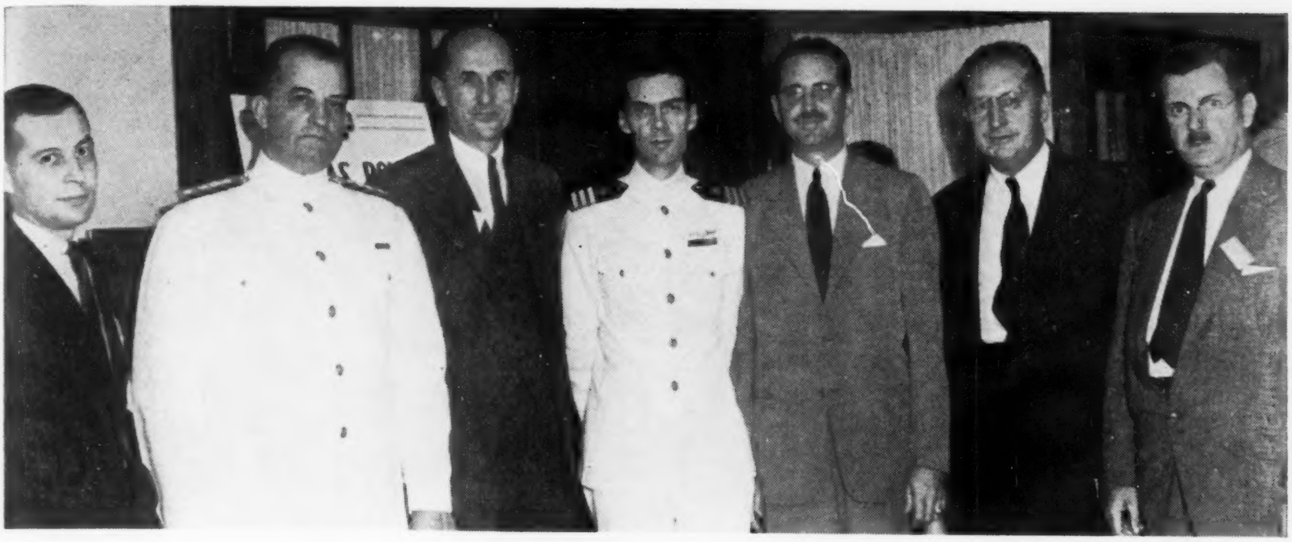
Joint Conference Committee on Piping Codes and Standards

SINCE the approval and publication of the American Standard for Steel Pipe Flanges and Flanged Fittings in 1939 (ASA B16e–1939) and the American Standard Code for Pressure Piping in 1942 (ASA B31.1–1942) the interlocking of certain parts of these publications with the A.S.M.E. Boiler Construction Code has become increasingly evident. From time to time certain informal conferences have been held between small groups appointed by each committee to consider certain particularly urgent subjects. It is realized, however, that adequately to handle the discussions of the subjects of interest to the three groups a joint conference committee should be formed, composed of representatives of these three committees and representatives of the piping-installation contractors.

This Joint Conference Committee on Piping Codes and Standards held its first meeting in New York, N. Y., on June 3, 1943. The personnel of the committee is as follows: C. A. Kelting, *chairman*, Sabin Crocker, E. P. Everhard, F. C. Fantz, V. M. Frost, E. D. Grimison, A. M. Houser, Alfred Iddles, J. R. Kruse, F. H. Morehead, D. B. Rossheim, and J. H. Zinc.

Members of Sectional Committees B16 and B31 who have noted conflicts between the three publications are urged to call them to the attention of the joint committee by addressing a letter to Chairman C. A. Kelting, care of the A.S.M.E.

[2] Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. Mem. A.S.M.E.



AMONG THOSE PRESENT AT THE OIL AND GAS POWER CONFERENCE IN BALTIMORE

(*Left to right:* J. M. Mousson, chairman, Publicity Committee, Rear Admiral Earle W. Mills, Bureau of Ships, U.S.N., speaker at the Banquet J. A. Worthington, chairman of the Inspection Trip Committee, and the man responsible for taking the Conference to Baltimore; Commander Thomas G. Reamy, Bureau of Ships, U.S.N.; E. P. Geary, assistant vice-president, Rustless Iron and Steel Corporation; R. W. Dietrich; P. B. Jackson, toastmaster at the Banquet.)

Diesel Engines in Naval Service Theme of 16th National Oil and Gas Power Conference

Rear Admiral E. W. Mills Speaker at Banquet

With Diesel horsepower in naval use multiplied one-hundredfold in the last twenty years, development of this type of engine forms a vital phase of the war effort. To foster this development by bringing together the designers and builders of Diesel engines and their sea going customers, the Oil and Gas Power Division built the program for its 16th National Oil and Gas Power Conference around the Diesel in naval service. With the splendid co-operation of the Bureau of Ships, U.S.N., the meeting, held June 14–16, at the Lord Baltimore Hotel, Baltimore, Md., drew a record crowd of 300 engineers.

Welcome Luncheon Opens Meeting

A Welcome Luncheon officially opened the Conference. W. P. Hill, chairman of the Baltimore Section and conference chairman, welcomed the members of the Division and their guests and introduced the chairmen of the various conference committees, whose efforts made the meeting possible in spite of wartime restrictions. Past-president A. G. Christie, honorary conference chairman, joined in expressing the hospitality of Baltimore members of the A.S.M.E., and E. S. Dennison, chairman of the OGP Executive Committee, responded with the thanks of the Division.

More than 200 engineers crowded the first technical session, at which Commander Thomas G. Reamy, Bureau of Ships, U.S.N., presented "Diesel Maintenance in the Navy," a comprehensive and timely paper which aroused lively and valuable discussion.

Admiral Mills Speaker at Banquet

Further statement of the Navy's viewpoint came from the speaker at Monday evening's banquet, Rear Admiral Earle W. Mills, assistant chief, Bureau of Ships, U.S.N. Dealing with "Some Aspects of Navy Main Propulsion With Respect to Diesel Engines," the Admiral commended the Diesel industry for technical development and production expansion and expressed great interest in the future of the Diesel in naval service. However, he warned that the desire, on the part of the Navy and of the engine builders, to secure maximum output per unit of weight had led to lack of conservatism in rating engines. Co-operation in establishing a standard of rating would benefit both the industry and the Navy, he said. Toastmaster P. B. Jackson introduced the Admiral to the 285 members and guests present and outlined his distinguished career.

PROF. A. G. CHRISTIE EXTENDS GREETINGS TO THE CONFERENCE AT THE WELCOME LUNCHEON ON JUNE 14

Splendid Inspection Trips

Those members able to present suitable credentials were accorded the rare privilege of visiting the U. S. Naval Experiment station at Annapolis. The trip, held on Tuesday, June 15, was made by train, it having proved impossible to charter a boat. However, the interest attaching to the varied and comprehensive laboratory facilities at the Experiment Station far outweighed any minor discomforts involved in hot-weather traveling.

Another high spot of the three-day meeting was the inspection trip, on the evening of Wednesday, June 16, to the plant of the American Hammered Piston Ring Division of Koppers Company. After a delicious seafood buffet supper, which proved the abilities of the Koppers men as hosts, the engineers had a chance to see what goes into the making of piston rings—from the millions of precision rings for aircraft engines to the giant 6-ft rings for the low-pressure cylinders of Liberty Ship engines. Special interest attached to the new chromium-plating shop, believed to be the largest in the world, and to the new and splendidly equipped metallurgical laboratory.

Women Have Enjoyable Program

The women attending the meeting found a most hospitable welcome and enjoyed an interesting round of activities which started with an informal movie party on Monday afternoon and included the banquet on Monday evening and a luncheon and impromptu musicale on Wednesday afternoon. On Tuesday the women made the trip to Annapolis, lunching at famed old Carvel Hall and touring the historic town and the grounds of the Naval Academy under the guidance of Mrs. W. F. Joachim. The women also attended the buffet supper and inspection trip through the American Hammered Piston Ring plant.

A major part of the credit for the success

of the meeting goes to the Baltimore Section whose wholehearted co-operation made such matters as registration, credential-checking for the inspection trips, the women's program, the banquet and luncheon, and the technical sessions move smoothly and pleasantly. The committees for the Conference were as follows:

General Arrangements

William P. Hill, *chairman*
A. G. Christie, *honorary chairman*
H. Hollerith, *vice-chairman*
E. B. Whitman, *honorary vice-chairman*
L. E. Carter, *secretary-treasurer*

Mrs. A. G. Christie	R. J. Green
R. C. Dannettel	J. M. Mousson
B. W. Deringer, Jr.	S. F. Robertson
E. S. Freeman, Jr.	J. A. Worthington

Entertainment

S. F. Robertson, *chairman*
R. H. Roy — E. J. Benjes

Exhibits

E. S. Freeman, Jr., *chairman*

Inspection Trips

J. A. Worthington, *chairman*
P. B. Jackson — E. S. Freeman, Jr.

Women's Program

Mrs. A. G. Christie, *chairman*
Mrs. B. C. Higgins — Mrs. E. B. Whitman
Mrs. S. F. Robertson — Mrs. J. A. Worthington

Meetings

B. W. Deringer, Jr., *chairman*

H. P. Abbott	M. C. Dooley
J. B. Aldridge	R. D. Guerke
A. F. Brown	J. E. Onnen

H. Severin

Publicity

J. M. Mousson, *chairman*
C. F. Merriam — L. N. Rowley

Reception

R. C. Dannettel, *chairman*
A. G. Christie — S. B. Sexton
E. B. Whitman

Registration

R. J. Green, *chairman*
J. R. Schietinger — John Doering
Julian Spencer

New Subcommittee on Code for Pressure Piping

WITH the approval and publication of the first revised edition of the American Standard Code for Pressure Piping, Chairman E. B. Ricketts decided to name a new subcommittee to handle in a systematic manner the inquiries received concerning the scope and intent of the code.

The personnel of this subcommittee is as follows: Sabin Crocker, *chairman*, L. D. Burritt, C. S. Cole, Alfred Iddles, C. A. Kelting, F. H. Morehead, and J. Howard Williams.

DURING THE BANQUET ON MONDAY EVENING, JUNE 14, AT THE CONFERENCE OF THE OIL AND GAS POWER DIVISION OF THE A.S.M.E. IN BALTIMORE, MD.

(At the speakers' table from left to right are: Mrs. A. G. Christie, Prof. A. G. Christie, honorary chairman of the Conference and past-president of the A.S.M.E., Rear Admiral Earle W. Mills, speaker of the evening; P. B. Jackson, Aluminum Company of America, toastmaster; R. C. Dannettel, chairman of the reception committee; Ezra B. Whitman, honorary vice-chairman of the Conference and president of the A.S.C.E.; standing and talking to Mr. Whitman, J. M. Mousson, chairman of the Publicity Committee; Mrs. Ezra B. Whitman; R. L. Sackett, dean emeritus of engineering, The Pennsylvania State College; Miss Hollerith, H. Hollerith, vice-chairman of the Conference.)

W.P.B. Launches Campaign to Conserve Tool Alloys

MANAGEMENT, labor-management committees, and tool foremen in the metal-working industries are being asked to join actively in a campaign launched by the War Production Board to foster conservation of critical tool alloys which includes the adoption of tool-tipping procedures as a definite plant-wide practice.

Tipping of high-speed tools is urged by government specialists in the Tools and Conservation Division as an immediate "must" program so that no slowing down of production will occur later for lack of plentiful supplies of tool steels. The economies thus realized in the consumption of tool steel will be exactly reflected in a greater number of cutting tools and in a greater degree of sustained production.

Methods and technics for brazing and welding of tipped tools in accordance with procedures recommended by the manufacturers of tool steels have been compiled in a chart just released by the Tools and Conservation Divisions of W.P.B. Foremen, toolmakers, and other workmen may see at a glance the apparatus and materials needed for each tool-tipping procedure as well as the proper sequence of operations to be followed, with low-temperature and high-temperature brazing as well as resistance flash welding and pressure welding.

Brazing procedures are outlined for hardened high-speed steels; for butt joints, etc.; for brazing with copper and for brazing with ferroalloy cement. Welding procedures are shown for hardened high-speed steel; for welding annealed high-speed blanks to simple steel shanks, (1) not for subsequent forging, and (2) for subsequent forging; and for pressure welds for joining high-speed stubs to simple steel shanks.

Plant groups or officials may obtain special assistance and data on the care of tools by writing the Conservation Division, War Production Board, Washington, D. C.

"Mechanical Engineering" Sent to Army Camps

IN common with other national engineering societies, The American Society of Mechanical Engineers, at the suggestion of a subcommittee of the Committee on Professional Training, Engineers' Council for Professional Development, has been sending complimentary copies of MECHANICAL ENGINEERING to military posts where reading rooms are provided. Replies to letters asking if the service was sufficiently useful to warrant its continuance for another year have brought affirmative responses from librarians in charge of reading rooms and many appreciative comments.

MECHANICAL ENGINEERING is currently being sent free of charge to about 150 libraries and reading rooms at military camps.

Do You Want a 1944 A.S.M.E. Catalog?

The A.S.M.E. Catalog department stresses the need for prompt reservation of 1944 copies. To comply with paper-conservation requirements and for the proper number of copies for advertisers, every member desiring a copy of the 1944 Catalog should reserve it by return mail.

A.S.M.E Council Meets, June 13–14, at Los Angeles, Calif.

A MEETING of the Council of The American Society of Mechanical Engineers was held at the Biltmore Hotel, Los Angeles, Calif., Jun 13 and 14, 1943, in connection with the 1943 Semi-Annual Meeting. Two sessions were held, one on Sunday afternoon and the second on Monday morning.

There were present: Harold V. Coes, president; Warren H. McBryde, past-president; Joseph W. Eshelman, Clair B. Peck, and Willis R. Woolrich, vice-presidents; William G. Christy, Herbert L. Eggleston, and Roscoe W. Morton, managers; Oliver B. Lyman (Local Sections); A. J. Dickie (guest); Ernest Hartford, executive assistant secretary; and John E. Younger, secretary, aviation division. At the Sunday session there were also present J. Calvin Brown, chairman, and J. S. Gallagher, member, of the Executive Committee of the Southern California Section; and D. C. A. Bosworth, comptroller. At the Monday session there were also present D. K. Coyle, of the Executive Committee of the Southern California Section; B. P. Graves, chairman of the Nominating Committee; and M. J. Thompson and John A. Willard, guests.

1943-1944 Budget

The Council approved the estimate of income and the Budget of Expenditures for 1943–1944, as shown on this page.

Members of the Council reported visits they had made to local sections and student branches, and J. Calvin Brown reported a most successful War Production Clinic at Los Angeles, held under the auspices of the Southern California Section, with an attendance in excess of 3000. Ernest Hartford reported that 16 annual meetings of Student Branches had been held out of 18 scheduled.

At the instance of Joseph W. Eshelman an expression of appreciation of Col. James L. Walsh's contributions to the Society and of his addresses at meetings of local sections was recorded.

Amendments to By-Laws Voted

Amendments to the By-Laws of the Society, B5, Par. 9, and B14, Par. 16, were adopted. The amended By-Laws relate to dues of student members and the handling of funds and expenditures.

1943 Awards

On recommendation of the Board of Honors and Awards the following awards for 1943 were approved:

A.S.M.E. Medal, Lewis K. Sillcox.

Holley Medal, Vannevar Bush.

Worcester Reed Warner Medal, Igor I. Sikorsky.

Joint Meeting With E.I.C. Approved

The Council voted to approve the holding of a Fall Meeting at Toronto, Canada, September 30–October 1, 1943, jointly with The Engineering Institute of Canada.

Brown Appointed to the Council

Owing to the resignation of Herbert L. Eggleston, J. Calvin Brown, of Los Angeles, Calif., was appointed as a manager to serve until Dec. 3, 1943. The Nominating Committee was requested to nominate a candidate for the office of Manager, to fill the unexpired term of Mr. Eggleston in 1944.

A vote of appreciation of the services of Mr. Eggleston as a member of the Council was recorded.

War Production Clinics

A form of organization for a national plan of War Production Clinics, submitted by P. T. Onderdonk, was accepted by the Council.

R. F. Gagg was appointed representative of the Society on the Consultative Engineering Committee of the War Manpower Commission.

Vote of Thanks

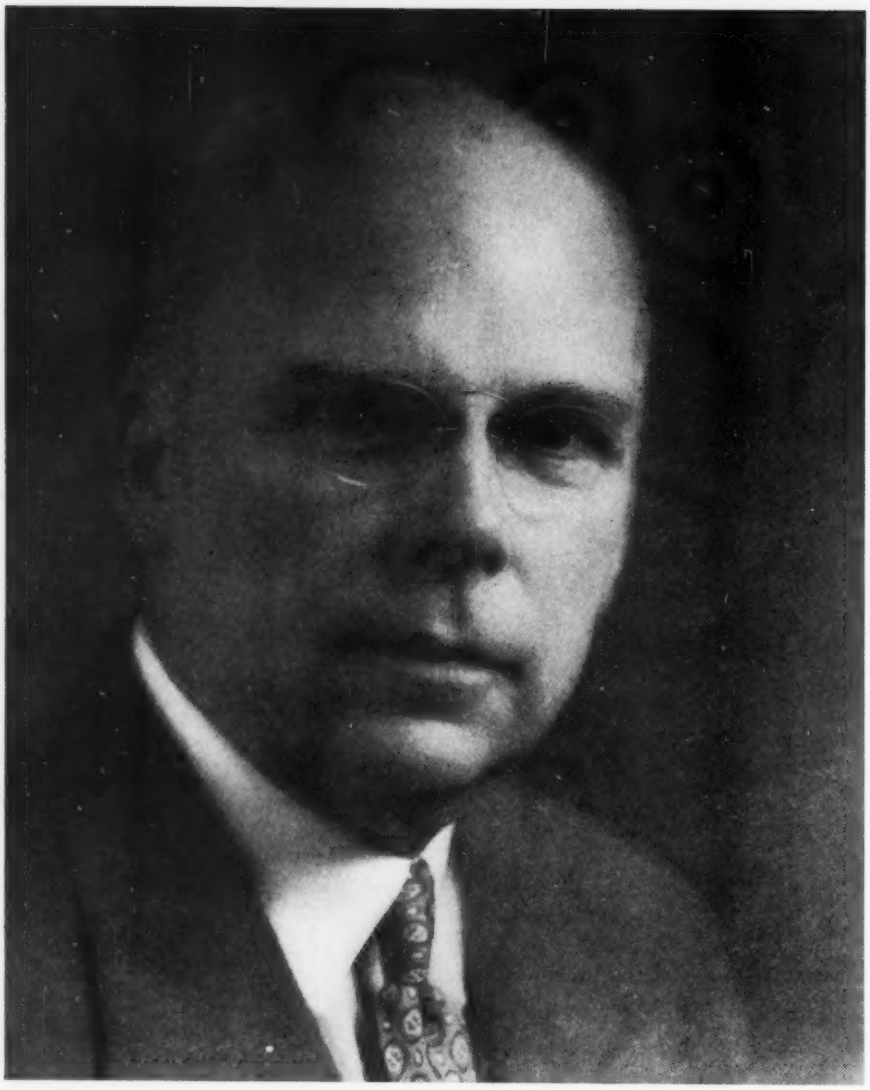
The Council voted "to extend its grateful appreciation to the Los Angeles Committee and sincere thanks to the chairman, J. Calvin Brown, and his associates, for their splendid work which culminated in an unusually successful meeting."

ESTIMATED BUDGET FOR 1943–1944 ADOPTED BY THE COUNCIL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
JUNE, 1943

Activity	Expense under committee supervision	Printing and distribution	Direct office expense	Total
Council	$ 4,500.00	....	....	$ 4,500.00
Library	9,831.00	....	....	9,831.00
Finance Committee	115.00	....	....	115.00
Nominating Committee	850.00	....	....	850.00
Awards	950.00	....	$ 394.00	1,344.00
Local Sections	28,800.00	....	8,267.00	37,067.00
Meetings and Program	7,300.00	....	9,917.00	17,217.00
Professional Divisions	3,700.00	....	14,015.00	17,715.00
Admissions	....	....	4,784.00	4,784.00
Employment Service	2,000.00	....	....	2,000.00
Membership Development	2,500.00	....	500.00	3,000.00
Aviation	....	....	3,750.00	3,750.00
Student Branches	8,960.00	4,500.00	5,315.00	18,775.00
Technical Committee	1,000.00	....	22,736.00	23,736.00
Transactions	200.00	38,700.00	16,086.00	54,986.00
MECHANICAL ENGINEERING, text	....	29,000.00	13,851.00	42,851.00
Membership List	....	5,500.00	1,274.00	6,774.00
MECHANICAL ENGINEERING, advertising	....	36,400.00	34,317.00	70,717.00
A.S.M.E. Mechanical Catalog	....	25,200.00	26,480.00	51,680.00
Publications for Sale	....	32,500.00	11,009.00	43,509.00
Reserved for Boiler Code	....	8,000.00	....	8,000.00
Retirement Fund	7,700.00	....	....	7,700.00
E.C.P.D.	850.00	....	....	850.00
General committee expense	100.00	....	....	100.00
Professional services	1,500.00	....	....	1,500.00
Committee on Registration	350.00	....	....	350.00
Organization charts	125.00	....	....	125.00
Secretary's office	....	....	17,820.00	17,820.00
Accounting	....	....	21,263.00	21,263.00
General service	....	....	34,967.00	34,967.00
General office expense	....	....	19,242.00	19,242.00
Publicity	4,000.00	....	....	4,000.00
	$85,331.00	$179,800.00	$265,987.00	$531,118.00

ESTIMATED INCOME FOR 1943–1944 ADOPTED BY THE COUNCIL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
JUNE, 1943

Income	Actual 1941–1942	Budget 1942–1943	Estimate 1943–1944
Initiation and Promotion Fees (to Surplus)	$ 11,565.35	$ 10,000.00	$ 10,000.00
Membership dues	232,626.70	236,000.00	236,000.00
Student dues	24,998.85	20,700.00	15,000.00
Interest and discount	5,449.46	3,800.00	5,000.00
MECHANICAL ENGINEERING, advertising	127,741.52	155,000.00	138,000.00
Mechanical Catalog, advertising	57,062.86	57,000.00	57,000.00
Publications sales	74,016.63	75,000.00	80,000.00
Miscellaneous sales	2,601.06	2,500.00	2,500.00
Contributions, *Journal of Applied Mechanics*	1,100.00	500.00	....
Engineering Index, Inc	....	798.00	500.00
Registration fees	698.00	405.00	500.00
Sale of equipment	104.50	35.00	....
Membership List Advertising	603.00	....	500.00
Total income	$527,002.58	$551,738.00	$535,000.00
To be added to surplus	23,171.96	22,444.00	3,882.00
Balance for Expense	$503,830.62	$529,294.00	$531,118.00



Robert M. Gates

Nominated for President

A.S.M.E. OFFICERS *Nominated for* 1943-1944

AT A MEETING in Chicago on May 29, 1943, of the National Nominating Committee of The American Society of Mechanical Engineers, R. M. Gates, president of the Air Preheater Corporation, New York, N. Y., was nominated for the office of President of the Society for the year 1943–1944.

Vice-Presidents named by the Committee to serve two-year terms on the Council of the A.S.M.E. were David W. R. Morgan, Philadelphia, Pa.; Jonathan A. Noyes, Dallas, Texas; Ford L. Wilkinson, Jr., Louisville, Ky.; and Rudolph F. Gagg of Paterson, N. J.

Managers of the Society to serve on Council for three-year terms included James M. Robert, New Orleans, La., Samuel H. Graf, Corvallis, Oregon, and Alton C. Chick, Providence, R. I.

During the 1943 Semi-Annual Meeting of The American Society of Mechanical Engineers in Los Angeles, Calif., June 13–14, 1943, Herbert L. Eggleston tendered his resignation to the Council as Manager of the Society. The Council then appointed J. Calvin Brown of Los Angeles, Calif., to serve the term of Manager until December 3, 1943. Inasmuch as Mr. Eggleston's term on the Council would have expired December, 1944, the Nominating Committee has added J. Calvin Brown's name to the nominations for 1944 officers to serve one year as Manager, to December, 1944 to fill the unexpired term.

Members of the committee who were in attendance at Chicago and made the nominations were: B. P. Graves, Providence, R. I., chairman, representing Group I; G. J. Nicastro, New York, N. Y., Group II; V. M. Palmer, Rochester N. Y., Group III; James Ellis, Kingsport, Tenn., Group IV; Warner Seely, Cleveland, Ohio, secretary, Group V; G. L. Larson, Madison, Wis., Group VI; E. P. Weiser, Portland, Ore., Group VII; and A. L. Hill, Denver, Col., Group VIII.

Election of A.S.M.E. officers for 1944 will be held by letter ballot of the entire membership, closing September 28, 1943. A ballot will be mailed to every member in good standing on August 19.

Biographical sketches of the nominees follow on the succeeding pages:

Nominated for President

Robert M. Gates

ROBERT M. GATES, nominee for President of The American Society of Mechanical Engineers, is a Fellow of the Society, president and director of the Air Preheater Corporation, formerly vice-president of The Superheater Company and its affiliate, Combustion Engineering Company, Inc., all of New York, N. Y. He was born in O'Brien County, Iowa, Sept. 7, 1883, and studied at the Manual Training High School, Indianapolis, Ind., and at Purdue University, where he received the degree of bachelor of science in mechanical engineering in 1907.

From 1907 to 1909 Mr. Gates was associated with the Browning Company of Cleveland, Ohio, after which he practiced as consulting engineer until 1912 when he became associated with the Thew Shovel Company of Lorain, Ohio. In 1918 he became Eastern manager for the Lakewood Engineering Company of Cleveland, Ohio, and located in Philadelphia, Pa. In 1922 he became associated with The Superheater Company.

Mr. Gates has participated in the design and construction connected with the builders of fuel-burning and steam-generating equipment, including all types of boilers, stokers, pulverized-coal equipment, economizers, air preheaters, and superheaters for stationary, railway, and marine service, as well as a wide variety of heavy equipment for the process industries. Outstanding among their installations are the world's largest high-pressure boilers each producing over a million pounds of steam per hour.

Mr. Gates is a registered professional engineer in New York State and has long been active in the affairs of The American Society of Mechanical Engineers since becoming a member in 1918. He served as manager, 1928–1931, and as vice-president, 1931–1933, and he has been a member of various standing committees, including those on Meetings and Program and Professional Divisions. At the time of the World Power Conference in 1936 he was chairman of the Reception Committee. He has been serving as a member of the War Production Committee of the Society since 1942.

For the 1941 Annual Meeting of the Society Mr. Gates, as chairman of the Committee on Conservation and Reclamation of Materials in Industry, organized a "panel of experts" to conduct a session on conservation and reclamation. He served also as chairman of the first and many subsequent War Production Clinics which the A.S.M.E., at the request and with the assistance of the War Production Board, has been conducting for more than a year in industrial centers throughout the nation.

Mr. Gates has made numerous addresses before various engineering groups and given much time to counseling junior and student members of the Society. His keen interest in the problems of young engineers and engineering students is probably traceable to the fact that he supported himself during his entire education, including the high school period, when he sold tickets in the Indianapolis Union Station.

Mr. Gates has written many articles and given a number of talks on handling of materials, power generation, personnel direction, and management. Aside from his engineering activities he finds time to take considerable interest in civic and economic affairs of Scarsdale, N. Y., of which he is a resident, and of Westchester County, N. Y. He is a member of the National Industrial Conference Board, is on the Board of Arbitration of the American Arbitration Association and on the Advistory Board of the National Economic League.

He is also a member of the following organizations: Newcomen Society of England, American Institute of Electrical Engineers, National Association of Manufacturers, National Association of Professional Engineers, American Management Association, American Iron & Steel Institute, The Engineers Club of New York, the Union League Club of New York, the Downtown Athletic Club of New York, the Manursing Island Club of Rye, N. Y., and the Scarsdale Golf Club, Scarsdale, N. Y.

Nominated for Vice-Presidents

DAVID W. R. MORGAN

JONATHAN A. NOYES

RUDOLPH F. GAGG

FORD L. WILKINSON, JR.

David W. R. Morgan

DAVID W. R. MORGAN, nominated for the office of Vice-President of The American Society of Mechanical Engineers is works manager of the steam division, Westinghouse Electric & Manufacturing Company, Philadelphia, Pa. He was born in Martin's Ferry, Ohio, September 16, 1892, and received the degree of M.E. from Ohio Northern University in 1913.

He entered the employ of the Westinghouse Electric & Manufacturing Company as a technical apprentice in 1913. He has been promoted successively as follows: assistant engineer, 1916; engineer, 1917; manager of condenser, pump, and Diesel-engine division, 1926; assistant manager of engineering, 1940; manager of manufacturing, 1941. He was appointed to his present position of works manager in April, 1943.

Mr. Morgan originally joined the Society in 1918. He served on the Condenser Research Committee from 1925 to 1931, and later, from 1933 to 1939. He has been a member of the Power Test Codes Committee No. 12 on condenser, water-heating, and cooling equipment since 1933. He was appointed a member of the Admissions Committee in January, 1943.

The civic activities of Mr. Morgan cover his service as president of the Swarthmore Borough Council and as a member or the Health Committee of the Philadelphia Chamber of Commerce and Board of Trade. He is also a member of the Engineers Club of Philadelphia.

Jonathan A. Noyes

JONATHAN ALVAN NOYES, nominated for the office of Vice-President of The American Society of Mechanical Engineers, was born in Waltham, Mass., December 25, 1889. He received his B.S. degree from Massachusetts Institute of Technology in 1912.

Mr. Noyes has spent the last 31 years with the Sullivan Machinery Company, manufacturers of mining, quarrying, and oil-field machinery. His first assignments included shopwork and sales engineering. He then became manager of the Lake Superior iron and copper mining district, and later general manager of the coal-machinery division at Chicago. More recently he has been product and division manager, petroleum machinery, at Dallas. He has participated in the design, development, and application of underground and open-pit coal- and metal-mining machinery and exploration, drilling, and production machinery for the oil fields.

As a student, Mr. Noyes was chairman of the A.S.M.E. Student Branch at Massachusetts Institute of Technology. He joined the Society as a junior member in 1916 and became a member in 1925. He has been chairman of the A.S.M.E. War Production Conference, and at present he is chairman of the North Texas Section of the A.S.M.E.

Mr. Noyes has served as president and director of the Duluth Engineers Club, as director of the Minnesota Federation of Architectural and Engineering Societies, and as president of the Duluth Chapter of the International Professional Institute.

At present, Mr. Noyes is president of the Technology Club of North Texas, a member of the American Institute of Mining and Metallurgical Engineers, the American Petroleum Institute, president of the Southwest Conference of Unitarian Churches, and honorary secretary in residence for Massachusetts Institute of Technology. He is a registered professional engineer and a member of the Dallas Athletic Club.

Ford L. Wilkinson, Jr.

FORD L. WILKINSON, Jr., nominated for the office of Vice-President of The American Society of Mechanical Engineers was born in Elkton, Kentucky, August 15, 1895. He is a graduate of the U. S. Naval Academy, class of 1918. After taking a postgraduate course in mechanical engineering at the U. S. Naval Academy in 1924 he entered Columbia University and received the degree of master of science in 1925.

Mr. Wilkinson served on the U.S.S. *Denver*, July, 1917, to March, 1918; on the U. S. chartered transport *Re d'Italia*, March, 1918, to August, 1918, as a convoy officer; on the U. S. receiving ship *New York*, August, 1918, to January, 1919, as aide to executive officer; on the U.S.S. *Delaware*, January, 1919, to May, 1921, as turret officer. From May, 1921, to August, 1921, he attended the U. S. Submarine School at New London, Conn. He then was promoted to executive officer and chief engineer on the U. S. Submarine O-6, serving from August, 1921, to May, 1922. From May, 1922, to May, 1923, he was commanding officer of the U. S. Submarine O-1, and engineer officer Submarine Division No. 4. From September, 1925, to July, 1927, he was commanding officer of the U. S. Submarine S-18. He resigned in 1927 with the rank of Lieutenant, U.S.N.

In 1928 he entered the firm of Wilson-Weesner-Wilkinson Company, Nashville, Tenn., as a sales engineer, and in that year he was appointed chief engineer, Bureau of Smoke Regulation, Knoxville, Tenn. In January, 1930, Mr. Wilkinson became associated with the Riley-Stoker Corporation, Worcester, Mass., on development and engineering research on steam generators and pulverized coal. In 1933 he joined the faculty of the University of Tennessee as assistant professor, and was successively associate professor, professor, and head of the department of mechanical engineering. From 1938 to the present he has been associated with the University of Louisville, Louisville, Kentucky, as dean of engineering of the Speed Scientific School.

He has acted as a consultant in steam-power-plant design and operation to the Tennessee Valley Authority, Tennessee State Public Utilities Commission, and various industrial plants. He is a regional adviser for Kentucky and Southern Ohio on engineering, science, and management war-training program of the War Manpower Committee. Dean Wilkinson has contributed many articles to technical publications over a number of years.

Dean Wilkinson became an associate member of the A.S.M.E. in 1926 and a member in 1929. He has been particularly active in his work for the Society in connection with the Local Sections, serving this year as chairman of the Standing Committee. He belongs also to the Society for the Promotion of Engineering Education and is a member of Sigma Tau, Tau Beta Pi, and Phi Kappa Phi. He is a registered professional engineer in the states of Tennessee and Kentucky.

Rudolph F. Gagg

RUDOLPH FARWELL GAGG, nominated for Vice-President of The American Society of Mechanical Engineers, was born in Denver, Col., in 1902. He attended the University of Colorado on a four-year scholarship. After receiving his B.S. degree in 1923 he attended the Sheffield Scientific School at Yale University for two years of postgraduate work and received the M.E. degree.

In 1925 he started his professional career in experimental engineering as junior engineer in engine development work with the Climax Engineering Company in Clinton, Iowa. After two years spent in Diesel-engine development he worked for two years on gasoline engines for industrial use and was made assistant chief engineer. He also made a thorough market survey for use in planning the future manufacturing and marketing policies of the company.

In 1930 he entered the Wright Aeronautical Corporation as senior test engineer and was shortly advanced to experimental engineer in charge of the fabrication and testing of experimental aircraft engines. In 1934 he was made assistant chief engineer and added administrative work to his experimental-engineering duties. The organization of test procedures and construction of special apparatus for use in engine research work was an important part of this work. He initiated an extensive training program for junior engineers which has proved to be an important influence in developing additional technical personnel needed to sustain the company's part in the war program.

In 1940 he was transferred to the staff of the general manager of the Wright Aeronautical Corporation. As a part of plans for manufacturing expansion to meet increasing requirements of military aviation, he conducted a survey of available plant facilities which led to a specific course of expansion over the ensuing period. This plan called for maximum utilization of near-by vacant plant facilities prior to construction of new buildings. In the subsequent course of this work, thorough plant-location studies were made before determining upon a site for an aircraft-engine-manufacturing plant in Ohio. This very large construction program was accomplished under his supervision and was unique for the times in that it was accomplished within a preplanned budget. The results achieved were used as a yardstick by government officials in measuring the performance of others.

During this period of construction activity he was drafted to act as consultant to the National Advisory Committee for Aeronautics on the design of its new Aircraft Engine Research Laboratory in Cleveland, which is the most extensive research equipment project ever undertaken at one time.

He has been an active member of The American Society of Mechanical Engineers since 1923 and has served on various committees. He is now chairman of the Aviation Division, member of the Board on Technology, and of the Committee on Publications. He is a Fellow of the Institute of Aeronautical Sciences and is a member of the Society of Automotive Engineers, Tau Beta Pi, and Sigma Xi.

JAMES M. ROBERT

SAMUEL H. GRAF

ALTON C. CHICK

J. CALVIN BROWN

Nominated for Managers

James M. Robert

JAMES M. ROBERT, selected as a candidate for the office of Manager of The American Society of Mechanical Engineers, was born in St. Paul, Minn., June 20, 1885. He received his degree of B.E. in mechanical and electrical engineering in 1906 from Tulane University.

From 1906–1912 Dean Robert served as an instructor at Tulane University. He successively progressed at this University as assistant professor of experimental engineering, associate professor of machine design, professor of mechanical engineering, acting dean of the college of engineering, and, since 1936, dean of the college of engineering.

Dean Robert has had considerable experience as a consulting and testing engineer since 1906. In the first World War he was in charge of the U. S. Shipping Board of the Marine Engineering School at Tulane from 1917 to 1921.

He has been a member of the Society since 1920, serving as chairman of the New Orleans Section in 1923 and 1924. He was secretary of the Louisiana Engineering Society for eleven years, becoming vice-president in 1923 and president in 1924. He served as editor of the Proceedings of that society for many years.

Dean Robert is also a member of the Society for the Promotion of Engineering Education and was vice-chairman of the Southeastern Section in 1937 and 1938 and chairman from 1938 to 1939. He served as a member of the Board of Examiners of Operating Engineers from 1934 to 1941 in New Orleans, La. He belongs to Tau Beta Pi, Sigma Phi Delta, Omicron Delta Kappa, and Pi Kappa Alpha fraternities.

Recently he was selected as panel member of the War Labor Board and he is a member of the Board of Directors of the Pendleton Shipyards, Inc.

Samuel H. Graf

SAMUEL H. GRAF, nominated for the office of Manager of The American Society of Mechanical Engineers was born in Portland, Oregon, August 4, 1887. He received his B.S. in E.E. in 1907, E.E. in 1908, B.S. in M.E., 1908, M.E. in 1909, and M.S. in E.E. in 1909 all from Oregon State College.

Since 1908 Professor Graf has been connected with Oregon State College. He started as an assistant in the mechanical-engineering department. After several years as instructor and assistant professor in mechanical and experimental engineering he was appointed head of the department of experimental engineering in 1912, and two years later, professor. From 1920 to 1934 he served as professor of mechanics and materials. He has also been director of engineering research since 1927. Since 1934 he has been professor of mechanical engineering and head of that department.

Professor Graf has had an active consulting practice, serving as research engineer for about four years with the Portland Gas and Coke Company, in research work in safety of appliances for the American Gas Association Testing Laboratory, and as research engineer with the Iron Fireman Manufacturing Company. He was consulting engineer from 1935 to 1937 for the Bonneville Power and Navigation Project and has been a consulting engineer for the Willamette Valley Project since 1936. He spent one summer conducting comprehensive tests on four suction dredges operated by Port of Portland and was test engineer in sixteen trial trips of merchant vessels built in Portland, Oregon. He was a test engineer with the U. S. Shipping Board, Portland, Oregon, for one year.

First appointed by Governor Patterson and later reappointed by Governor Meier in 1931, Professor Graf has served as a member of the State Board of Engineering Examiners since 1927, representing the field of mechanical engineering, and has been president of the Board since 1939. He was director of the western zone of the National Council of State Boards of Engineering Examiners from 1934 to 1936. In 1936–1937 he was vice-president and in 1937–1938 he served as president of N.C.S.B.E.E.

In addition to his many outside engineering connections he has worked on many and various problems in the testing laboratories of his own department at Oregon State College. These investigations and tests have included work on structural materials, highway materials, fuels, and lubricants. He has also been engaged as consultant on inventions and a wide variety of problems brought to the college for solution.

As faculty editor of *Oregon State Technical Record* since the start of that publication, Professor Graf has contributed many semitechnical articles to its pages. He was co-author of the Gas Appliance Testing Code published by Pacific Gas Association and editor of the "Gas Engineers' Handbook," a reference work of about 1000 pages, published in 1934, by McGraw-Hill Book Company, Inc., New York, N. Y.

Professor Graf joined the Society in 1912 and is a past-chairman of the Oregon Section of the A.S.M.E., past vice-president of the Northwestern Society of Highway Engineers, past-president of the Oregon Chapter of the American Society for Metals, and a member of the Pacific Coast Gas Association. He has served twice on the Nominating Committee of the A.S.M.E. and has been honorary chairman of the A.S.M.E. Student Branch at Oregon State College. He is a registered professional engineer of the state of Oregon and is a past-president of the Corvallis Engineers Club.

Professor Graf belongs to the honorary fraternities of Tau Beta Pi, Sigma Tau, Pi Tau Sigma, Eta Kappa Mu, Sigma Xi, and Phi Kappa Phi.

(*Nominations continued on following page*)

Alton C. Chick

ALTON C. CHICK, who has been nominated for the office of Manager of The American Society of Mechanical Engineers, was born in Limerick, Maine, October 26, 1896. He received his B.S. degree from Brown University in mechanical engineering in 1919 and his M.S. degree in civil engineering in 1926.

During his junior year at Brown University, Mr. Chick enlisted in the U. S. Navy. He was placed on inactive duty to attend a ten weeks' course in mechanical engineering at Brown University thus completing his senior year's work in that time. After this course, he was assigned to the U. S. Navy Steam Engineering School, Stevens' Institute of Technology, Hoboken, N. J., from which he was commissioned an Ensign, and assigned to sea duty on the naval transport *U.S.S. Montpelier*. In June, 1919, he was honorably discharged from the Navy and was invited to return to Brown University in September of that year to serve as an instructor in mechanical engineering, which position he held for two years. The summer vacation of 1920 was spent by Mr. Chick as a draftsman in the Philadelphia Inspection Department of the Associated Factory Mutual Fire Insurance Companies, and in June, 1921, he returned to this Inspection Department and spent the following year inspecting industrial plants in the states from New York to Florida.

In June, 1922, Mr. Chick became principal assistant to John R. Freeman, consulting engineer and president of six of the Associated Factory Mutual Fire Insurance Companies. He remained with Mr. Freeman until his death in October, 1932. During this ten-year period, he had an opportunity to work on many and varied engineering problems.

Just prior to Mr. Freeman's death in 1932, Mr. Chick undertook to recompute an extensive series of experiments on the flow of water in pipes and pipe fittings that were made by Mr. Freeman at Nashua, N. H., in 1892. Unfortunately, Mr. Freeman died before this work could be completed, but after his death the work was carried on by others under the supervision of Mr. Clarke Freeman and Mr. Chick, and the results were published by the A.S.M.E. in 1941, in a volume of 349 pages entitled "Experiments Upon the Flow of Water in Pipes and Pipe Fittings."

After Mr. Freeman's death, Mr. Chick accepted a position as engineer with the Manufacturers Group of six Fire Insurance Companies, later merged, in July, 1941, in the one company, known as the Manufacturers Mutual Fire Insurance Company. In January, 1938, he was made assistant vice-president and engineer of the company, the position which he now holds. His work with the insurance company involves application of engineering principles to the prevention of fire and the protection of industrial plants against interruption of production and loss by fire and other perils. His duties also involve the underwriting and rating of fire-insurance risks.

Mr. Chick joined the Society as a Junior in 1921 and became a member in 1934. He has served as a member of the Executive Committee of the Providence Section of the A.S.M.E. and was its chairman 1934–1935. He was a member of the A.S.M.E. Committee on Relations With Colleges from 1937 to 1942 and was chairman of this Committee during the fifth year.

He has served on various committees and in various official capacities for the Providence Engineering Society and was its president during the year of 1937 to 1938. He was treasurer of the Brown Alumni of Brown University from July, 1937, to July, 1943, and is now vice-president of the Brown University Engineering Association. Mr. Chick was treasurer of the Eastern Section of the Seismographical Society of America for three years, from 1937 to 1939.

At present Mr. Chick is a member of the Providence Law Revision Committee, appointed by Mayor Roberts in January, 1942, to draft a new building code for the city of Providence and also a member of the Staff of the Civilian Defense Council in both the city of Providence and state of Rhode Island. He is deputy director of the utilities divisions of the Providence CD Council and a member of the utility division of the State Council.

J. Calvin Brown

J. CALVIN BROWN, nominated for the office of Manager of The American Society of Mechanical Engineers, attended public and high schools in Los Angeles and the California Institute of Technology.

He studied law at Hamilton College where he received the degrees of L.L.B. and L.L.M. He also attended special courses at Southwestern University and the University of Southern California, with an additional course in petroleum at the Petroleum Institute.

At present Mr. Brown is attorney at law and mechanical engineer, specializing in patent, trade-mark, and copyright litigation before the United States Courts. He has been admitted to the bars of California, Illinois, and the District of Columbia.

Mr. Brown became a member of the Society in 1928 and is past-chairman of the Southern California Local Section. As general chairman of the Committee handling the A.S.M.E. Semi-Annual Meeting in Los Angeles in June of this year, Mr. Brown did a magnificent job in co-ordinating all efforts to make the meeting the success that it was.

He is past-president of the Patent Law Association of Los Angeles, vice-president of the International Adventurers Club, a member of the Society of Motion Picture Engineers, of the Society for the Advancement of Science, and of the National Aeronautics Association.

At the Semi-Annual meeting of the A.S.M.E. in Los Angeles, Calif., Mr. Brown was appointed to fill the unexpired term of Herbert L. Eggleston until December 3, 1943. The Nominating Committee then added his name to the nominations for 1944 officers of the Society to serve one year as Manager to December, 1944.

Industrial Instruments and Regulators Division

THE Executive Committee of the newly formed Industrial Instruments and Regulators Division of The American Society of Mechanical Engineers held its organization meeting on June 25 at headquarters in the Engineering Societies Building. The entire Executive Committee was present, including Everett S. Lee, chairman; J. C. Peters, secretary; Ed S. Smith, E. D. Haigler, and I. M. Stein.

This meeting was for the purpose of outlining the work of the new Division and coordinating it with the activities of the former Committee on Industrial Instruments and Regulators of the Process Industries Division, from which it was formed.

The Committee on Industrial Instruments and Regulators was started in December, 1936, mainly through the efforts of Ed S. Smith. It was established as a Committee of the Process Industries Division in 1937. In the ensuing five years the Committee attracted a membership of some 80 engineers interested in the theory, design, and application of industrial instruments and regulators.

Since measurements are fundamental in engineering and as control is prominent throughout, there was recognition that the activities of the subcommittee were of interest to most of the Professional Divisions of the Society. Petition to be granted Division status was favorably acted upon by the Standing Committee on Professional Divisions on January 15, 1943, and by the Executive Committee of Council on January 27, 1943. The new Division is deeply indebted to the Process Industries Division for its early life history and for the encouragement given to form a Division. This, together with the formation of the Rubber and Plastics Group, is the second offspring from the Process Industries Division in two years, a tribute to this group of such great and fundamental importance not only in our Society but in the industrial and engineering world.

The Executive Committee of the Industrial Instruments and Regulators Division looks forward to the organization of members of all grades interested in promoting the arts and sciences in that branch and, in addition to the members of the past Committee, invites all others interested to add their contributions to the work. Names may be registered by writing to Ernest Hartford, Executive Assistant Secretary, A.S.M.E. Headquarters, 29 West 39th Street, New York, N. Y.

EVERETT S. LEE.[1]

[1] Chairman, A.S.M.E. Industrial Instruments and Regulators Division.

Among the Local Sections

Annual Dinner of Minnesota Section Has Many Interesting Features

MINNESOTA SECTION OF A.S.M.E. DINNER

(*Left to right at the speakers' table are:* Mrs. L. B. Schaeffer, chairman of the mechanical engineering building committee of the Minnesota Federation of Women's Clubs, Mrs. Sudgen, president of the Minnesota Federation of Women's Clubs, Mrs. Thomas S. McEwan, Thomas S. McEwan, manager of the A.S.M.E. and speaker of the evening, L. C. Sprague, chairman of the Minnesota section of the A.S.M.E., president Frank B. Rowley, head of the mechanical engineering department, University of Minnesota.)

On May 26 the Minnesota Section held its annual dinner party at which 38 members and guests were present.

Prof. B. J. Robinson in discussing plans for the new mechanical engineering building to be built on the University of Minnesota campus presented some interesting side lights of the early history of engineering at the University of Minnesota and introduced guests and members of the group who were active in the campaign for the building appropriation. Among those who were recognized for their efforts were Russel Backstrom, chairman of the mechanical engineering alumni committee; Mrs. L. B. Schaeffer, chairman of the mechanical engineering building committee of the Minnesota Federation of Women's Clubs; Mr. Donald Heng, chairman of the aeronautical alumini committee; Mrs. Sudgen, president of the Minnesota Federation of Women's Clubs, and Prof. Frank B. Rowley, Mem. A.S.M.E., chairman of the mechanical-engineering department at the University of Minnesota.

Appropriation of $1,175,000

Professor Rowley discussed plans for the building which will include 188,420 square feet of floor space, covered by a building appropriation of $1,175,000. L. C. Sprague, chairman of the Minnesota Section of the A.S.M.E., also expressed his appreciation to those who were active in the building campaign, and a motion was carried to write a letter on behalf of the Section to the state legislature for the building appropriation.

W. H. Erskine, the new chairman of the Section, outlined the broader program for the coming year with particular emphasis on the need for engineers to prepare for the postwar period. Mr. Erskine then called on Professor Rowley who presented a certificate of recognition to Mr. Sprague for his contribution to mechanical-engineering progress in the Northwest with special emphasis on his accomplishments in improving the equipment, financial condition, and mechanical equipment of the Minneapolis and St. Louis Railroad, of which Mr. Sprague is president.

Mr. Sprague responded and cited further examples of accomplishments in reducing the expense of accidents in the railroad from $1,443,000 per year to $62,000 per year over a four-year period. Another example of the results accomplished was the completion of ballasting of 509 miles of main line track.

T. S. McEwan Speaker of Evening

The speaker of the evening was T. S. McEwan, Mem. A.S.M.E., vice-president of McClure, Hadden & Ortman, Inc., of Chicago. Mr. McEwan's subject was "The Mechanical Engineer Today and After the War." He stated that most of the ninety billion dollars that America will spend this year for war purposes will be spent under the direction of engineers, and that both quality and quantity production are required to win the war. He cited examples of navy work on which the original emphasis was on quality alone but in which the designs were adapted for more economical production without any impairment of quality; he also gave examples of cost reduction and increased production through better tooling, improved methods, materials control, and selection of suitable materials.

He stated that the A.S.M.E. is playing an important part in the war effort with many of the members in executive positions with the Ordnance and other departments of the Government. In discussing the outlook for the future, Mr. McEwan mentioned developments in the fields of electronics, new fuels, global air transport, new drugs, new metals and chemicals, and agricultural production. Many of these developments have come from the war program and will be instrumental in creating a better peacetime world of the future. He called upon the members of the Section to be "real engineers of reconstruction and progress."

Present-Day Steam Generator Discussed at Anthracite-Lehigh

At a meeting on May 28 the Anthracite-Lehigh Section heard John Phillips Badenhausen, Mem. A.S.M.E., of Day & Zimmermann, Philadelphia, Pa., speak on "Development of the Present Day Steam Generator." He discussed the difficulties encountered in boiler problems and how often the solution was so simple that the engineer was apt to follow all other angles first. Membership awards to outstanding students in mechanical engineering were given to Philip H. Powers, Jr., Lehigh University, and to John S. Attinello of Lafayette College. After the meeting a chicken dinner was served to the 63 members and guests attending.

Reorganization Meeting at Anthracite-Lehigh Valley

On June 18 the Anthracite-Lehigh Valley Section held its reorganization meeting at Riverview Lodge, Northampton, Pa. J. A. Gish, chairman of the Section, briefly sketched the activities of the past year under wartime conditions which necessitated reducing the number of meetings from eight to four for the 1942–1943 period. Attendance and interest

were splendid at all meetings with the high-point being the (Bethlehem-Easton) meeting at the Hotel Penn-Stroud, Stroudsburg, Pa., on May 28. Chairman "Jimmie" was given a rising vote of thanks for his efforts in the handling of the local Section.

Mrs. Paul B. Eaton read several letters from Professor Eaton, Mem. A.S.M.E., written during his trip to Chungking, which told of some of his experiences. At the conclusion Mrs. Eaton was given a rising vote of thanks for the opportunity of hearing from the Section's friend and councilor, Professor Eaton.

After the business meeting an interesting talk was given by Prof. Wm. E. Reaser of Lafayette College.

Milwaukee Section Holds Discussion Meeting

The Milwaukee Section met on May 12 with an attendance of fifty members for the purpose of acquainting local members with the local and national society structure, council, by-laws, and local contract with the Milwaukee Engineers' Society. The discussion was a spirited one and was followed by a talk given by Herbert Moore on "A National Society for Professional Registered Engineers," based on state registration laws.

New Orleans Section Reports on Activities

The New Orleans Section held ten meetings during the 1942–1943 period, including joint meetings with the A.I.E.E., A.S.H.&V.E., Louisiana Engineering Society, Tulane Student Branch of A.S.M.E., and Rotary, as well as the all-embracive War Production Clinic. One speaker came from New York, and another from Chicago to address the meetings. Technical papers dealt with shell manufacture, aviation, industrial rubber applications, and railway Diesel equipment, while discussion of logistics, naval officer procurement, and inland waterways were interspersed between the more specialized papers. This Section now holds membership in the New Orleans Association of Commerce, and its representative functions on one of the important committees of that association. This organization also participated actively in the Second War Loan Drive of the U. S. Treasury's War Finance Committee, securing bond purchases of more than $4000. One of its members, Dean James M. Robert, has been nominated by the Society's Nominating Committee for election to the office of Manager of the Society.

Classic Art of Measurement, Talk by Everett S. Lee at W. Virginia Section

The West Virginia Section held its last meeting of the 1942–1943 year at the Daniel Boone Hotel in Charleston, West Virginia, on May 25. A dinner was given in honor of Everett S. Lee, engineer in charge of the General Electric laboratory of the General Electric Company of Schenectady, N. Y., who gave a talk on "Measuring Instruments as Applied to Industry." He illustrated his talk by the use of lantern slides. Mr. Lee presented a series of extremely interesting stories of the invention and development of a dozen or more modern measuring devices from the spectrometer, to the complicated device used for measuring the voltage and duration of 2,000,000-volt lightning flashes striking power transmission lines. Mr. Lee combined the precise know-how of a top-flight engineer-scientist with a very clear and concise manner of presentation which enabled all present to appreciate the vast field of the art of measurement.

Following the lecture a sound film was shown on "Curtiss Wright Answers the call for Quantity." This film showed a step-by-step development of a P-40 fighter from the drawing board to final test flight.

With the Student Branches

Boomerangs and Steam Research at Purdue Branch

On June 2 the Purdue Branch met to hear Prof. J. I. Yellott, Mem. A.S.M.E., head of the division of mechanical engineering at the Illinois Institute of Technology, also head of the war program at that institution, give a fine talk on "Universal Problems in Steam Research." Before the lecture, members of the mechanical-engineering faculty and student officials of the chapter attended a dinner given in honor of Professor Yellott in the Chestnut Room of the Purdue Memorial Union. Professor Yellott has done considerable research on the flow of liquids through nozzles and jet propulsion.

The Purdue Branch, on June 16, heard a lecture on the "Boomerang" given by Prof. C. H. Robertson, a graduate of South Dakota College and Purdue University (Ph.D. 1926). In this lecture, a continuation of a previous discussion on the gyroscope, Dr. Robertson covered the fundamentals of the boomerang.

After the lecture the crowd of about 200 met outside and watched Dr. Robertson make his theory work. If anyone says that only the Australian aborigines can handle a boomerang skillfully and successfully he has not heard of Dr. Robertson. Not only did he throw the boomerang in graceful circles, but he also predicted every time just exactly what he was going to make it do. The spectators enjoyed the finale—Dr. Robertson made one of his boomerangs spin right over their heads.

On June 16 the George Washington Branch held its first meeting of the summer semester which followed a general "mixer" of engineering students from engineering societies at George Washington University. At the "mixer" members of the faculty present were introduced for the benefit of freshmen. Dean F. M. Feiker, Mem. A.S.M.E., delivered a few words on the "Wartime Developments in this Engineer-School and Future Possibilities."

The Kentucky Branch at its meeting on May 21, with Prof. C. C. Jett, Mem. A.S. M.E., in charge saw two interesting films; "Zinc Die Casting" by the New Jersey Zinc Company and "The Birthplace of Iceburgs" prepared by Father Hubbard, the glacier priest. A prize was awarded M. E. Mitchell for his paper prepared for the spring meeting in Knoxville. Prof. S. B. Walton was elected and installed as honorary chairman of the A.S. M.E. Student Branch and the Branch expressed its appreciation for the guidance given by Professor Jett in his many years as honorary chairman of the Branch.

NORTHEASTERN STUDENT BRANCH SMOKER

(*First row center,* Prof. J. Zeller, Mem. A.S.M.E.; *to his left,* Holcombe Brown, Mem. A.S.M.E., guest; N. Seavey, instructor; W. Mitchell, chairman; R. Beane, vice-president. *To the right of Professor Zeller* are Prof. A.E. Whittaker, honorary chairman; M. Ellion, treasurer, and N. Molino, secretary.)

A.S.M.E. Student Group Meetings, 1943

OUT of twenty group meetings of Student Branches scheduled for 1943, thirteen were held with 69 colleges in all participating, one was held in conjunction with a meeting of the Oregon Local Section, and six were canceled because of wartime conditions.

Following is a table which lists the A.S.M.E. Student Group meetings for 1943.

GROUP II—NEW ENGLAND STUDENT MEETING, SYRACUSE, N. Y., APRIL 9, 1943

Attendance: 55 Papers presented: 5

Prize	Recipient	Title of Paper	College
First	Horace C. Lowers	Machine-Time Analysis	Clarkson College of Technology
Second	Anthony J. Proterra	Water Relief Valves	Clarkson College of Technology
Third	Gertrude Hochgrat	Possibilities of Diesel Aircraft Engines	Syracuse University
Old Guard	E. S. Boyden	Government as Affected by Engineering	University of Vermont
Hon. Mention	Harry G. Sutton	Polarized Light and Photoelasticity	Syracuse University

GROUP III—NEW YORK, N. Y., APRIL 17, 1943

Attendance: 150 Papers presented: 5

Prize	Recipient	Title of Paper	College
First	Lawrence Lief	High-Speed Indicators	College of the City of New York
Second	Joseph A. Mazzola	Proposed Design for Explosion-Gas Turbine	Pratt Institute
Third	Herbert Becker	Adjustable Snap-Gage Problems	College of the City of New York
Old Guard	Gerald Selvin	Applications of Plastics	New York University

GROUP IV—PHILADELPHIA, PA., APRIL 19, 1943, DREXEL INSTITUTE OF TECHNOLOGY

Attendance: 175 Papers presented: 5

Prize	Recipient	Title of Paper	College
First	John S. Attinello	Wind Tunnels	Lafayette College
Second	Arthur E. Hammarlund	Application of Felt for Vibration	University of Pennsylvania
Third	Robert Young	Doubling Speed of Towing Tank Car	Princeton University
Fourth	John E. Corr	Vibroelectric Balancing-Machine	Drexel Institute
Fifth	Arthur G. Thorpe	High-Speed Internal-Combustion-Engine Indicator	Swarthmore College

GROUP V—COLLEGE PARK, MD., MAY 7, 1943, UNIVERSITY OF MARYLAND

Attendance: 140 Papers presented: 10

Prize	Recipient	Title of Paper	College
First	Edwin C. Kilgore	A Modern Ship's Rolling Doors	Virginia Polytechnic Institute
Second	Max Kerschensteiner	Rocket Propulsion	University of Maryland
Third	Robert E. Ponbranz	Establishing Methods Department in Modern Machine	North Carolina State
Old Guard	Martin Johnson	Future Application of the Alfaro Engine	Duke University

GROUP VI—PITTSBURGH, PA., APRIL 16, 1943, UNIVERSITY OF PITTSBURGH

Attendance: 140 Papers presented: 4

Prize	Recipient	Title of Paper	College
First	Harold A. List	Railroads	Carnegie Institute of Technology
Second	George Marinoff	Economic Aspects of Our Expendable Power Resources	University of Akron
Third	William Rudoy	Refrigeration Goes to War	University of Pittsburgh
Old Guard	Alfred Sullivan	Radiography	Carnegie Institute of Technology

GROUP VII—EAST LANSING, MICH., MAY 8, 1943

Attendance: 42 Papers presented: 4

Prize	Recipient	Title of Paper	College
First	Jack Merschel	Powder Metallurgy	University of Detroit
Second	August Sunnen	Modern Industrial Honing	Michigan State College
Third	Ben F. Olson	Welding in Commercial Shipbuilding	Ohio State University
Old Guard	John J. Linker	Synthetic Rubber	University of Michigan

GROUP XI—EVANSTON, ILL., APRIL 12-13, 1943, NORTHWESTERN UNIVERSITY

Attendance: 150 Papers presented: 10

Prize	Recipient	Title of Paper	College
First	Bernard S. Hattis	Detonation Characteristics in Diesel and Gasoline Engines	Northwestern University
Second	John H. Baker	The Design of Compensating Space Line Justifying Typewriter	Iowa State College
Third	Sylvester Lemezis	Poppet Valve Applied to Steam Locomotives	Marquette University
Old Guard	Karl L. Pennau	Domestic Stoker Installations	University of Wisconsin

GROUP XIII—MANHATTAN, KANSAS, APRIL 22-23, 1943, KANSAS STATE COLLEGE

Attendance: 104 Papers presented: 10

Prize	Recipient	Title of Paper	College
First	David Bendersky	Oil-Well Survey With Multiple-Shot Clinograph	Kansas State College
Second	Warren E. Snyder	Properties of Plastics in Bearing	University of Kansas
Third	Richard M. Phelan	Progress in Energy Balancing of Refrigeration Test Unit	University of Missouri
Old Guard	William A. Frusher	Electrode Salt Bath Furnace	Kansas State College

(*Continued on page 616*)

GROUP XIV—DALLAS, TEXAS, APRIL 20, 1943, SOUTHERN METHODIST UNIVERSITY

Attendance: 101 Papers presented: 12

Prize	Recipient	Title of Paper	College
First	Charles D. Axelrod	Antaiircraft Fire-Control Director	University of Oklahoma
Second	William J. Staton	Influence of Storage Conditions on Physical Properties of Lignite	University of Texas
Third	Morris Weingarten	Ignition Lag in Compression-Ignition Engines	A.&M. College of Oklahoma
Fourth	Hugh T. Campbell	Surface Hardening of Carbon Steels by Induction Heating	Southern Methodist University
Old Guard	Stuart F. Bird	Soil-Analysis Method of Geophysical Prospecting	University of Oklahoma
Sixth	Nathan Shapiro	The Gas Turbine	A.&M. College of Oklahoma
Seventh	Roy Allters, Jr.	Armament of Fighter Aircraft	Texas Technological College
Eighth	Charles N. Townsend	The University of Texas Dehydration Process	University of Texas
Ninth	Darwin Boesch	There Is a Better Way	A.&M. College of Texas
Tenth	Gordon King	Armament of Modern Aircraft	Southern Methodist University
Eleventh	Eugene N. Davidson	Air Conditioning of Underground Bombproof Shelters	Texas Technological College
Twelfth	James R. Latimer	That Extra Something	A.&M. College of Texas

GROUP XV—FORT COLLINS, COL., APRIL 9, 1943, COLORADO STATE COLLEGE

Attendance: 50 Papers presented: 5

Prize	Recipient	Title of Paper	College
First	Melvin M. Tongish	Method of Producing 100-Octane Aviation Gasoline	Colorado School of Mines
Second	J. Ellsworth Young	My Experiences With Pratt & Whitney	University of Wyoming
Third	B. Marsh Allen	Internal-Combustion Turbines	Colorado State College
Old Guard	Charles H. Hill	The Engineer as a Citizen	Colorado State College
Fifth	Rex Cheek	Synthetic Rubber in War Effort	Colorado School of Mines & Met.

GROUP XVI—PULLMAN, WASHINGTON, STATE COLLEGE OF WASHINGTON, MAY 10, 1943

Attendance: 25 Papers presented: 4

Prize	Recipient	Title of Paper	College
Old Guard	Robert Boring	Various Uses of Strain Gages	Washington State College
First	Robert Boring	Various Uses of Strain Gages	Washington State College
Second	Paul Radach	Improvements in Internal-Combustion Auxiliaries	Washington State College
First	Russel Wilson	Modern Gear-Cutting Methods	University of Idaho
Second	Tommy Takatori	Modern High-Speed Diesels	University of Idaho

PORTLAND, OREGON—OREGON STATE COLLEGE, HELD JOINTLY WITH OREGON LOCAL SECTION

Attendance: 40 Papers presented: 4

Prize	Recipient	Title of Paper	College
First	Ed DeKoning	Heat Transfer to Lubricating Oil of Internal-Combustion Engine	Oregon State College
Second	William Miller	Stress Analysis by X-Ray Diffraction	Oregon State College
Third	Archie Fanger	Eddy-Current Dynamometers	Oregon State College
Fourth	William Love	Gas Turbines	Oregon State College

GROUP XVII—STANFORD UNIVERSITY, CALIF., STANFORD UNIVERSITY, APRIL 17, 1943

Attendance: 39 Papers presented: 7

Prize	Recipient	Title of Paper	College
First	Thomas Carvey	Analytical Bases for Quick-Freezing Operations	Stanford University
Second	Cedric Ferguson	Design Calculations for Finned-Cylinder Cooling	Stanford University
Third	James Selna	Engine Scavenging	University of Santa Clara
Old Guard	Joseph Lepetich	Artificial Converters of Solar Energy	University of Santa Clara

GROUP XIX—NEW MEXICO STATE COLLEGE, STATE COLLEGE, NEW MEXICO, APRIL 10, 1943

Attendance: 35 Papers presented: 8

Prize	Recipient	Title of Paper	College
First	Arthur Williams	Physical Properties, Uses and Compounding of Thiokol	University of New Mexico
Second	Fred S. Fiedler	Manufactured Weather at Magna	University of Arizona
Third	George E. Ellis	The Other Half of Engineering	University of Arizona
Fourth	Edward C. Rightley	Lubrication of Internal-Combustion Engines	University of New Mexico

(Continued from page 615)

A meeting of May 20 of the Missouri Branch was devoted to the election of new officers: Prof. A. H. Burr, honorary chairman; John Tendick, student chairman; Arthur Zeitz, vice-chairman; Richard Schmidt, treasurer, and George Tretiak, secretary.

Ships and Planes of Navy at Northeastern

Northeastern Student Branch enjoyed a smoker on May 26. The guest speaker, Holcombe Brown, Mem. A.S.M.E., Boston consulting engineer, and a member of the A.S.M.E., Committee on College Relations, spoke on "Future Engineering for the Young Engineer." After his talk the March of Time films on "Ships and Planes of the U. S. Navy" were shown.

Northwestern Branch held its meeting on May 19. New officers were elected: Donald Robb, chairman; Paul Buhrke, vice-chairman, and Bruce Wiley, secretary. As the Navy is putting a large percentage of the engineers in uniform on July 1, there is some question as to what lies ahead for this Branch. Indications are at present that they will be able to meet evenings, both civilians and Navy men. No definite planning seems possible.

N.Y.U. Evening Branch held its business meeting in June to elect new officers for 1943–1944. New officers are, R. M. Jensen, chairman; E. E. Woods, vice-chairman; Miss C. H. Northcote, secretary; S. S. Rudy, treasurer; and Prof. J. G. Barrie, honorary chairman.

The first meeting of the summer term was held on June 15 by the Oklahoma A.&M. Branch. Morris Weingarten was elected secretary-treasurer and Isaac Gassett elected corresponding secretary and reporter. Plans were made for future meetings, and a short talk by De Witt Hunt, head of industrial arts education, was followed by two films on "Industrial Safety."

The Tennessee Branch met on June 16 at which time newly elected officers were introduced and the new honorary chairman, Prof. F. H. Thomas, addressed the group, expressing his appreciation at being appointed to this

(A.S.M.E News continued on page 618)

NO. 7 OF A SERIES

HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

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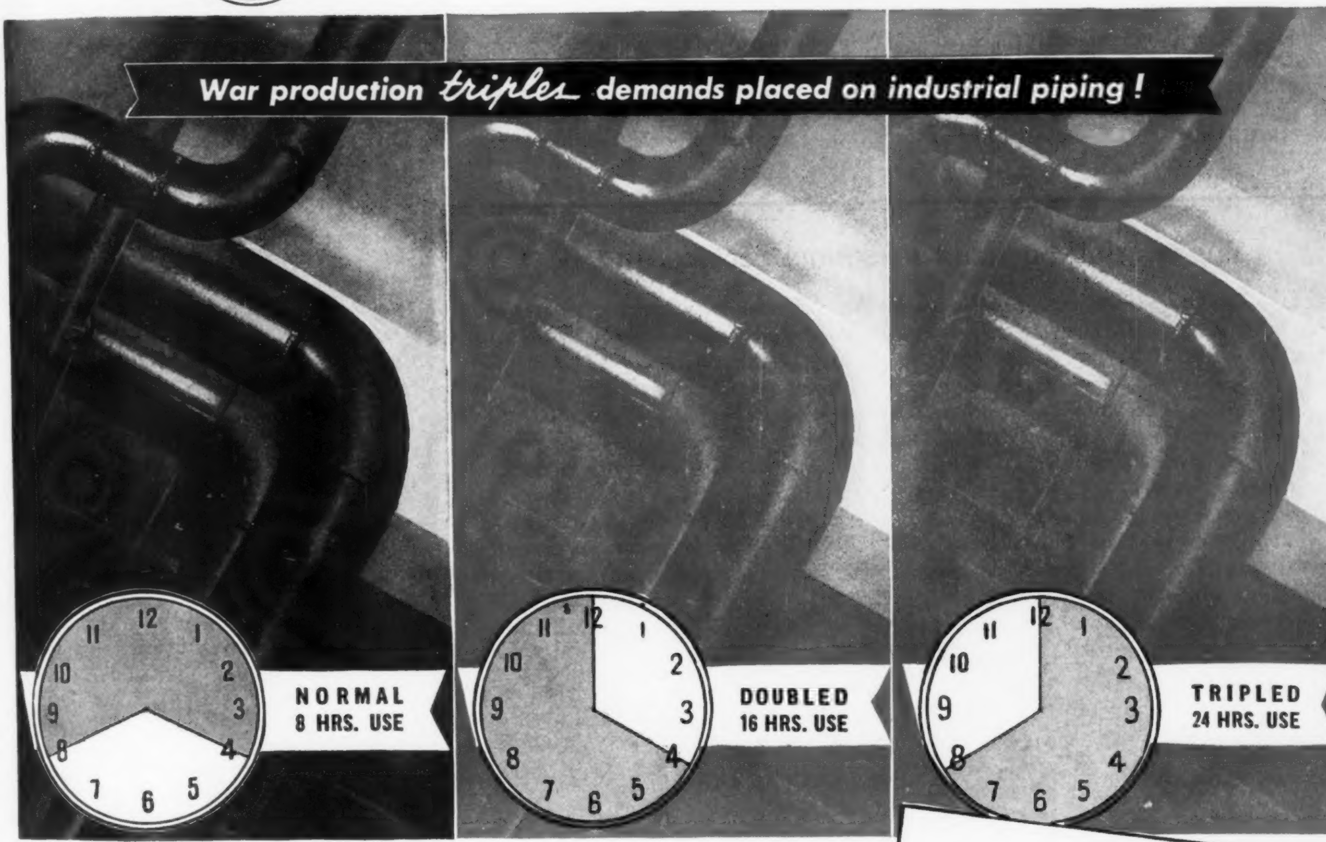

'ROUND the clock, war-time operation for 24 hours a day instead of the normal 8 hours period *triples* the wear of oil, gas, power, chemical, heating, air, refrigeration and marine piping today.

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FEWER SUPPORTS NEEDED: Since welded piping weighs less and stands vibration better than flanged systems, few hangers or supports are required.

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office. He offered his services in all capacities and related a few of his previous experiences as honorary chairman of the Branch at the University of Illinois. Plans were made for an outdoor party on July 10 at the Big Ridge recreation grounds.

In April the UTAH BRANCH elected new officers. They are Clair Williamsen, chairman; Paul Shipley, vicechairman; Curtis Rhees, secretary; Prof. Geo. W. Carter, honorary chairman. Various circumstances have required that the newly elected officers take office immediately. During May the Utah Branch met again for their first meeting under the newly elected officers. A lecture was delivered by the honorary chairman, Professor Carter, on "Professional Attitudes of Engineers."

The WEST VIRGINIA BRANCH held its first meeting of the summer semester on June 7. J. Rowe, president of the Branch, gave a talk on organization and purpose of the organization. Instructions were given on the correct procedure of preparation and delivery of papers for subsequent meetings.

With reference to the film on "Wheels Across India" mentioned on page 539 of the July issue of MECHANICAL ENGINEERING, the name of the Chrysler Corporation was inadvertently omitted as the sponsor of the expedition.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York **8 West 40th St.**	**Boston, Mass.** **4 Park St.**	**Chicago** **211 West Wacker Drive**	**Detroit** **100 Farnsworth Ave.**	**San Francisco** **57 Post Street**

MEN AVAILABLE[1]

INDUSTRIAL ENGINEER, 8 years' top-notch record production management, organization, industrial relations, cost, methods. Cutbacks shrink scope of present responsibilities as chief industrial engineer. Desired: Opportunities to continue accomplishments. Me-808.

MECHANICAL ENGINEER, 33, experienced (two years foreign, ten years domestic) installation, operation, and maintenance of plumbing and heating, including oil burners, automatic equipment, and steam distribution systems. Me-809.

CHIEF ENGINEER OR CONSULTANT. Broad experience design and instruction of complete industrial, process, metallurgical, and chemical plants. Me-810.

POSITIONS AVAILABLE

MECHANICAL OR CHEMICAL, INDUSTRIAL OR METHODS ENGINEERS to study equipment and operations to increase production of materials manufactured. Experience as process engineer for chemical or oil company desirable. Must know theoretical side. Salary open. Maryland. W-2402.

MANAGER OF SMALL FACTORY specializing in ornamental iron and blacksmith work. Must be graduate mechanical engineer. Must also be good executive and able to estimate steel. Salary open. New York, N. Y. W-2403.

[1] All men listed hold some form of A.S.M.E. membership

ASSISTANT ENGINEER, not over 40, for iron and steel development. Should be graduate engineer, preferably in mechanical engineering, with some experience in other engineering fields such as civil and electrical, with broad background of experience in engineering of complete iron and steel plants and some knowledge construction of such plants. Will make immediate study of existing plant manufacturing wide sheared plates toward recommending economical alterations to improve and modernize plant. New York, N. Y. W-2409.

PROJECT ENGINEERS with good background radio manufacture. Able to take project from blueprint and follow through to final inspection. Must have some experience on small-parts manufacture. $6000 to $8000 year. New York, N. Y. W-2415.

DEVELOPMENT ENGINEER, 30–40, to work with sales department. Should have good working knowledge of how metal parts and equipment are fabricated. Experience in welding, brazing, soft soldering on production basis would be valuable. Accustomed to calling on leading manufacturers and co-operating with metallurgists, designers, and production men working out manufacturing problems. Salary open. Write giving complete information and draft status. New York, N. Y. W-2418.

PRODUCTION ENGINEERS, preferably men who have had some experience on production control, especially inventory control work. Company also needs man who has had some experience on job evaluation. $4000–$5200 year. New England. Headquarters, New York, N. Y. W-2431.

ENGINEERS. (*a*) Mechanical engineer, young, preferably experienced in steam engines, prime movers, or transmission of power, to assist research and marketing of new small engine. $3600–$4200 year. (*b*) Mechanical designer, not over 50, experienced in conveyer design and interested in board work. Salary open. Considerable traveling. Upper New York State. W-2436.

INDUSTRIAL MANAGEMENT ENGINEERS, 45–50, who have thorough knowledge of modern management and production problems. Prefer men who have actually worked up from bench and can still show mechanic how to do the job. Must have been in responsible charge of plant and be able to logically determine solutions to plant economic problems. $6500 year. Permanent. New York, N. Y. W-2449.

MECHANICAL ENGINEERS, CHEMICAL ENGINEERS, AND PHYSICISTS. Particularly need one or two men to take responsible charge of parts of project. Should preferably know something of explosives or be able to learn this subject readily. Also need younger men to work under project supervisors. Can use chemical, mechanical engineers, and design draftsmen. Apply by letter giving complete information. $3500–$5000 year. Illinois. W-2453C.

DEVELOPMENT ENGINEERS, 30–50, with good fundamental training electrical engineering or mechanical engineering. Knowledge electro-mechanical devices such as ignition, small electrical controls, helpful, but previous experience not essential. Salary dependent upon experience. Indiana. W-2463CD.

WORKS MANAGER-EXECUTIVE with successful experience precision machinery. Must be able to take full charge of manufacturing. $7500–$10,000 year. California. W-2465.

WOODWORKING PLANT ENGINEER, prefer graduate mechanical, who has had well-rounded experience in woodworking plant. He should have directed labor, planned production, supervised design, and have good economic management sense. Salary open. Permanent. Northern New York State. W-2466.

MECHANICAL ENGINEER who has had good all-round industrial experience. Prefer man who has had some machine and tool design, some management, sales. The duties will involve direct management of small plant doing metal stamped product work. Salary open. Permanent. New England. W-2474.

FACTORY MANAGER for fiber plant in Mexico. Company is subsidiary of American company making fiber for dress and broom trade. Must have good production and administrative background, particularly on factory costs, motion study, and personnel. Must speak Spanish. $5000–$6000 year. W-2484.

MECHANICAL AND PLANNING ENGINEER, preferably someone who has had several years' engineering experience with large concern. Will work on postwar products, develop them, and decide after investigation if they are eligible to manufacture, and if so, lay out tooling and prepare them for production. $6000–$6500 year plus bonus system. New York State. W-2487.

PLANT MANAGER, graduate mechanical or chemical engineer preferred, to manage small

(*A.S.M.E. News continued on page 620*)

plastic plant. Must have knowledge of compression molding, be acquainted with sources of material supplies, and be capable executive. Permanent. $5000–$6000 year. New York, N. Y. W-2499.

SUPERINTENDENT for large manufacturing department of company manufacturing radio specialties. Must be good shopman, have some knowledge of metal and ceramic combinations and must know silver soldering. Salary, about $5200 year. Northern New Jersey. W-2502.

PLANT MANAGER with good technical as well as practical background, to take full control of labor for plant employing several hundred people and to co-ordinate and expedite production. Man with experience production of small precision parts desirable; aircraft parts experience would be helpful but not essential. Permanent. Salary good. New York metropolitan area. W-2510.

EXECUTIVE MECHANICAL ENGINEER, 9 years general shop practice, 10 years public utility operation, 2 years public-building power and maintenance, 12 years plant engineer large industries. Thoroughly experienced in plant design, construction, and maintenance, plant layout and organization. Me-811.

Electrical Engineers Elect Officers

NEVIN E. FUNK, fellow A.S.M.E., and vice-president in charge of engineering, Philadelphia Electric Company, Philadelphia, Pa., was elected president of the American Institute of Electrical Engineers for the year beginning August 1, 1943, as announced at the annual meeting of the Institute held in Cleveland, Ohio, during the national technical meeting of the Institute. The other officers elected were: *Vice-Presidents*, W. E. Wickenden, member A.S.M.E., Cleveland, Ohio; C. W. Ricker, New Orleans, La.; L. A. Bingham, Lincoln, Neb.; J. M. Gaylord, Los Angeles, Calif.; W. J. Gilson, Toronto, Canada; *Directors*, C. M. Laffoon, East Pittsburgh, Pa. (re-elected); C. W. Mier, Dallas, Tex.; S. H. Mortensen, Milwaukee, Wis.; *National Treasurer*, W. I. Slichter, fellow A.S.M.E. (re-elected), New York, N. Y.

The annual report of the Board of Directors, presented at the meeting, showed a total membership on April 30, 1943, of 20,161. In addition to three national technical meetings and two District technical meetings, 1540 meetings were held during the year by the local organizations of the Institute in the principal cities and educational institutions in the United States, Canada, and Mexico.

Necrology

THE deaths of the following members have recently been reported to headquarters:

Bennett, Thomas A., April 24, 1943
Darlington, Joseph F., May 22, 1943
DuCommun, Edward, June 9, 1943
Fralich, John S. Y., January 5, 1943
Gammon, Robert C., June 17, 1943
Geer, Henry E., March 6, 1943
Haddox, Louis C., April 11, 1943
King, Carl, June 25, 1943
Langhammer, William P., December 3, 1942
Marburg, Louis C., June 26, 1943
Roberts, Percival, Jr., March 6, 1943
Ross, David E., June 28, 1943
Serrell, John A., June 8, 1943
Seymour, James A., June 28, 1943
Townsend, Harry P., November 13, 1942
Young, Gilbert A., June 27, 1943

A.S.M.E. Transactions for July, 1943

THE July, 1943, issue of the Transactions of the A.S.M.E., contains:

Utilizing Pulverized Coal in the Metallurgical Industries, by C. F. Herington
The Dynamic Viscosity of Nitrogen, by W. L. Sibbitt, G. A. Hawkins, and H. L. Solberg
Tests of Steam-Pipe Insulation, by E. A. Allcut
Measurement of High Temperatures in High-Velocity Gas Streams, by W. J. King
Process Lags in Automatic-Control Circuits, by J. G. Ziegler and N. B. Nichols
An Analysis of Gas Pipe-Line Economics, by H. C. Lehn
1825-Lb-Pressure Topping Unit With Special Reference to Forced-Circulation Boiler, by F. S. Clark, F. H. Rosencrants, and W. H. Armacost
Mechanical Tests of Cellulose Acetate—III, by W. N. Findley
The Holding Power and Hydraulic Tightness of Expanded Tube Joints: Analysis of the Stress and Deformation, by J. N. Goodier and G. J. Schoessow
Experimental Investigation of Tube Expanding, by E. D. Grimison and G. H. Lee
Practical Aspects of Making Expanded Joints, by C. A. Maxwell
The Testing of Volute Springs, by Bernhard Sterne
Volute-Spring Formulas, by C. J. Holland
Notes on Secondary Stresses in Volute Springs, by H. O. Fuchs

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after August 25, 1943, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

Alexander, J. B., New Kensington, Pa.
Barr, H. V., Zanesville, Ohio
Bastante, A. M., Cambridge, Mass.
Bernhardt, LeRoy F., Fort Wayne, Ind.
Blair, S. M., New York, N. Y.
Blanchard, Arthur H., Orange, N. J.
Bose, C. R., Dacca, Bengal, India
Brown, Edwin H., Milwaukee, Wis. (Rt)
Cross, Sherman S., Marietta, Ga.
Davey, G. I., Warrawee, N.S.W., Australia
Deuster, Ralph W. (Lieut.), Fort Sill, Okla.
Doty, Albert J., Grand Rapids, Mich.
Drew, Wm. B. F., New York, N. Y.
Flythe, John T., Jr., Richmond, Va.
Frei, Jack E., New York, N. Y.
Gerritzen, H. K. (Lieut.), Dayton, Ohio
Grimes, Chas. E., Palmerton, Pa.
Harwood, Harry P., Canajoharie, N. Y.
Heath, Clifford J., West Englewood, N. J.
Huddle, H. E., Newport, Ky.
Johns, Henry B., Baldwin, N. Y.
Johnston, Carlton H., San Marino, Calif.
Kavanaugh, E. J., New York, N. Y.
Kent, Nicholas, Peoria, Ill.
Kerner, Jos. R., New York, N. Y.
Kulick, Sidney, Philadelphia, Pa. (Rt)
Lehrer, Daniel, Los Angeles, Calif.
Lewisohn, Richard, Jr., Hoboken, N. J.
Lieberman, Arthur A., La Habra Heights, Calif.
Ludlow, Ralph A., Salt Lake City, Utah
Malott, W. M., Walnut Creek, Calif.
Martin, Wm. T., Canajoharie, N. Y.
Miller, Chas. T., Dorchester, Mass.
Munz, Chas. A., Los Angeles, Calif.
Nelson, Prentiss C., Berkeley, Calif.
Oakhill, Frederic E., Wilmette, Ill.
Opila, F. A., Lansdowne, Pa.
Osborne, Latham E., Philadelphia, Pa.
Parker, Graham W., Silvermine, Norwalk, Conn.
Pearson, Tage B., New York, N. Y.
Purves-Smith, C. D., Pasadena, Calif.
Ryan, John M., Baltimore, Md.
Sandorff, Paul E., Glendale 7, Calif.
Schindler, Leon W., Barberton, Ohio
Semonin, Emmet V., Akron, Ohio
Smith, Marvin W., Pittsburgh, Pa.
Soderquist, L. E., Akron, Ohio (Rt)
Speicher, Paul J., St. Louis, Mo.
Staroba, Jos. F., Berwyn, Ill.
Stewart, Ross R., San Francisco, Calif.
Tauth, Geo., Naugatuck, Conn.
Thompson, Clyde H., Atlanta, Ga.
Walsh, J. Paul, Washington, D. C.
Weston, Wm. A., Oakmont, Pa.
Williams, R. S., Orrville, Ohio
Wilson, J. M., New York, N. Y.
Yavitch, J., Villanova, Pa.

CHANGE OF GRADING

Transfers to Member

Campbell, J. Alan, San Francisco, Calif.
Fitch, Roland C., South Bend, Ind.
Kohlmann, Gunter, Dobbs Ferry, N. Y.
Shirtley, S. L., Regents Park, N.S.W., Australia